National Greenhouse Gas Inventory Report of JAPAN

2016

Ministry of the Environment, Japan
Greenhouse Gas Inventory Office of Japan (GIO), CGER, NIES

Center for Global Environmental Research

National Institute for Environmental Studies, Japan

National Greenhouse Gas Inventory Report of JAPAN (2016)

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Foreword

On the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Decision 2/CMP.8, all Parties to the Convention and the Kyoto Protocol are required to submit national inventories of greenhouse gas emissions and removals. Therefore, the inventories on emissions and removals of greenhouse gases and precursors are reported in the Common Reporting Format (CRF) and in this National Inventory Report, in accordance with the UNFCCC Inventory Reporting Guidelines (Decision 24/CP.19 Annex I) and Decision 2/CMP.8.

This Report presents Japan's national inventory arrangements, the estimation methods of greenhouse gas emissions and removals from sources and sinks, and the trends in emissions and removals for greenhouse gases (carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); sulfur hexafluoride (SF_6); and nitrogen trifluoride (NF_3)), precursors (nitrogen oxides (NO_X), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC)), and sulfur oxides (SO_x). Supplementary information under Article 7.1 of the Kyoto Protocol is presented as well.

The structure of this report is prepared in line with the structure indicated in the Appendix of the UNFCCC Inventory Reporting Guidelines.

The Executive Summary focuses on the latest trends in emissions and removals of greenhouse gases in Japan. Chapter 1 deals with background information on greenhouse gas inventories, national inventory arrangements, the inventory preparation process, methodologies and data sources used, key category analysis, QA/QC plan, and results of uncertainty assessment. Chapter 2 describes the latest information on trends in emissions and removals of greenhouse gases in Japan. Chapters 3 to 7 provide the details of estimation methods for the sources and sinks described in the *2006 IPCC Guidelines*. Chapter 8 comprises current status of reporting of the emissions from sources not covered by these guidelines. Chapter 9 provides the current status of reporting of indirect emissions of CO_2 and N_2O. Chapter 10 provides the explanations on improvements and recalculations (data revision, addition of new categories, etc.) made since the previous submission, and Chapters 11 through 15 provide supplementary information under Article 7.1 of the Kyoto Protocol. Annexes offer additional information to assist further understanding of Japan's inventory.

For the latest updates or changes in data, refer to the web-site (URL: www-gio.nies.go.jp) of the Greenhouse Gas Inventory Office of Japan (GIO).

April, 2016
Low-carbon Society Promotion Office
Global Environment Bureau
Ministry of the Environment

Preface

Under the Kyoto Protocol accepted by Japan in June 2002, quantified targets for reductions in emissions of greenhouse gases were set for each of the Annex I Parties including Japan. The target given to Japan for the first commitment period (five years from 2008 to 2012) was to reduce average emissions of greenhouse gases by six percent from the base year. At the same time, the Annex I Parties were required to improve the accuracy of their emission estimates, and to prepare a national system for the estimation of anthropogenic emissions by sources and removals by sinks of the aforementioned greenhouse gases by one year prior to the start of the commitment period. The GHG inventory has been therefore the authoritative data for Japan in reporting its progress toward the Kyoto Protocol's commitment. Since then, emission/removal estimation for the first commitment period has been done under this system, and with the last report submitted in 2014 and the review completed, Japan's achievement of its emission reduction target became definite (including Kyoto mechanism credits).

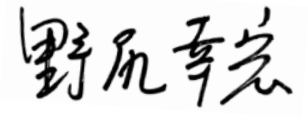
The GHG inventory of Japan including this report represents the combined knowledge of over 70 experts in a range of fields from universities, industrial bodies, regional governments, relevant government departments and agencies, and relevant research institutes, who are members of the Committee for the Greenhouse Gas Emissions Estimation Methods established by the Environment Agency (the current Ministry of the Environment) in November 1999 and held every year since.

In compiling the GHG inventory, the Greenhouse Gas Inventory Office of Japan (GIO) would like to acknowledge the contribution not only of the Committee members in seeking to develop the methodology, but of other experts who provided the latest scientific knowledge, the industrial bodies and government departments and agencies that provided the data necessary for compiling the inventory. We would like to express our gratitude to the Low-carbon Society Promotion Office of the Global Environment Bureau of the Ministry of the Environment, for their support to GIO.

This is the second submission of the inventory under the new UNFCCC Inventory Reporting Guidelines. By getting feedback from many internal and external reviewers, we have made further efforts to improve this report. We hope this report will be used widely and accurately as an index of what Japan should accomplish with regard to emission reductions, and as an index that shows the extent of Japan's measures implemented against global warming.

I also thank Ms. Yuriko ASANUMA (until December 2015) and Ms. Mutsuko FUJII, our assistants, who supported us with the smooth operation of GIO.

April, 2016



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Executive Summary of National GHGs Inventory Report of Japan

E.S.1. Background Information on GHGs Inventories, Climate Change

Japan reports the greenhouse gas (GHG) inventories, which contain the information on emissions and removals of GHGs, including indirect GHGs and SO_x in Japan for FY1990 to FY2014[1], on the basis of Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Decision 2/CMP.8.

Estimation methodologies of GHGs inventories are required to be in line with the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter, *2006 IPCC Guidelines*) which was made by the Intergovernmental Panel on Climate Change (IPCC), and Japan's estimation methodologies are basically in line with these guidelines. In order to enhance transparency, consistency, comparability, completeness and accuracy of inventory, Japan also applies the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Guidelines)* and *the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement (2013))*.

Japan's national inventory is reported in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (Decision 24/CP.19 Annex I, hereinafter referred to as the *UNFCCC Inventory Reporting Guidelines*) decided by the Conference of the Parties.

[1] "FY" (fiscal year), from April of the reporting year through March of the next year, is used because CO_2 is the primary GHGs emissions and estimated on a fiscal year basis. "CY" stands for "calendar year".

E.S.2. Summary of National Emission and Removal Related Trends

E.S.2.1. GHG Inventory

Total GHGs emissions in FY2014[2] (excluding LULUCF[3]) were 1,364 million tonnes (in CO_2 eq.). They increased by 7.3% compared to the emissions in FY1990 (excluding LULUCF).

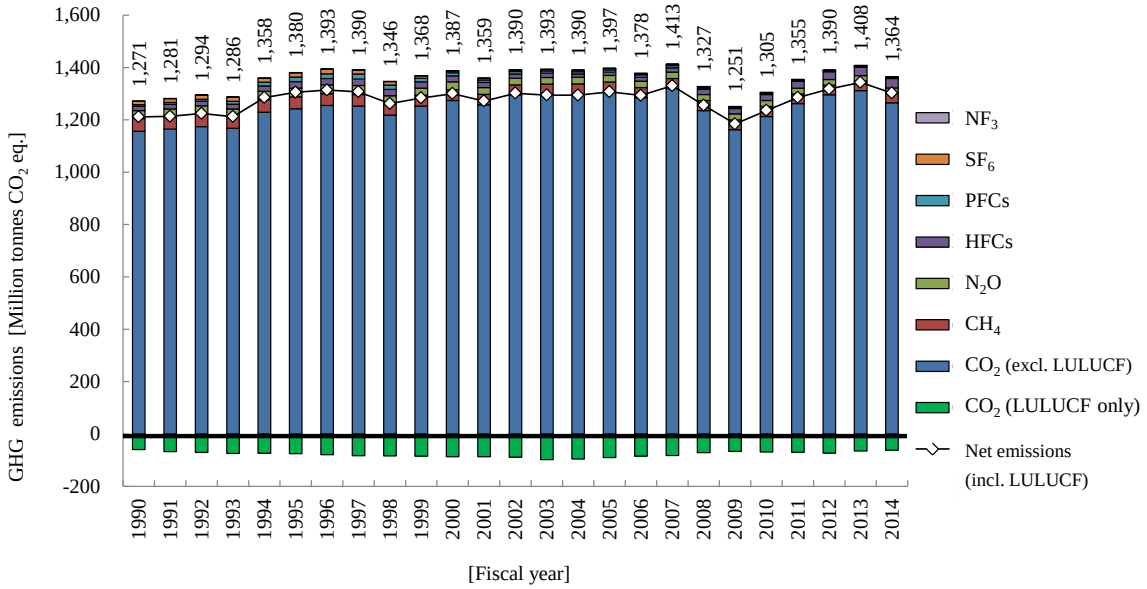


Figure 1 Trends in GHGs emission and removals in Japan

[2] The sum of CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3 emissions converted to CO_2 equivalents multiplied by their respective global warming potential (GWP). The GWP is a coefficient by means of which greenhouse gas effects of a given gas are made relative to those of an equivalent amount of CO_2. The coefficients are subjected to the *Fourth Assessment Report* (2007) issued by the IPCC.

[3] Abbreviation of "Land Use, Land-Use Change and Forestry"

Table 1 Trends in GHGs emission and removals in Japan

[Million tonnes CO_2 eq.]	GWP	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (excl. LULUCF)	1	1,156.0	1,164.5	1,174.6	1,167.7	1,228.9	1,242.5	1,255.3	1,253.1	1,218.3	1,253.1
CO_2 (incl. LULUCF)	1	1,096.4	1,096.7	1,104.2	1,093.5	1,155.5	1,167.5	1,175.7	1,170.2	1,134.3	1,168.6
CO_2 (LULUCF only)	1	-59.6	-67.8	-70.4	-74.2	-73.4	-75.0	-79.6	-82.9	-84.0	-84.4
CH_4 (excl. LULUCF)	25	48.6	46.9	48.1	42.8	47.9	45.8	44.5	43.7	41.4	41.4
CH_4 (incl. LULUCF)	25	48.7	46.9	48.1	42.9	48.0	45.9	44.6	43.8	41.4	41.5
N_2O (excl. LULUCF)	298	30.8	30.5	30.6	30.5	31.8	32.2	33.3	34.1	32.5	26.4
N_2O (incl. LULUCF)	298	31.1	30.7	30.9	30.8	32.1	32.4	33.5	34.3	32.7	26.6
HFCs	HFC-134a: 1,430 etc.	15.9	17.3	17.8	18.1	21.1	25.2	24.6	24.4	23.7	24.4
PFCs	PFC-14: 7,390 etc.	6.5	7.5	7.6	10.9	13.4	17.6	18.3	20.0	16.6	13.1
SF_6	22,800	12.9	14.2	15.6	15.7	15.0	16.4	17.0	14.5	13.2	9.2
NF_3	17,200	0.03	0.03	0.03	0.04	0.1	0.2	0.2	0.2	0.2	0.3
Gross total (excl. LULUCF)		1,270.7	1,280.9	1,294.4	1,285.9	1,358.3	1,379.9	1,393.1	1,389.9	1,345.8	1,367.9
Net total (incl. LULUCF)		1,211.4	1,213.5	1,224.3	1,212.0	1,285.2	1,305.2	1,313.8	1,307.3	1,262.2	1,283.7

[Million tonnes CO_2 eq.]	GWP	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (excl. LULUCF)	1	1,274.3	1,257.4	1,294.4	1,299.5	1,298.4	1,305.9	1,285.2	1,319.8	1,235.5	1,162.6
CO_2 (incl. LULUCF)	1	1,187.2	1,170.2	1,205.6	1,201.3	1,202.8	1,215.7	1,200.5	1,237.1	1,163.7	1,095.7
CO_2 (LULUCF only)	1	-87.1	-87.2	-88.8	-98.2	-95.6	-90.2	-84.7	-82.7	-71.7	-66.9
CH_4 (excl. LULUCF)	25	41.5	40.2	39.5	37.6	39.0	38.9	38.2	38.5	38.2	37.2
CH_4 (incl. LULUCF)	25	41.5	40.3	39.6	37.6	39.1	39.0	38.3	38.5	38.3	37.2
N_2O (excl. LULUCF)	298	29.0	25.5	25.0	24.9	24.9	24.5	24.5	24.0	23.1	22.6
N_2O (incl. LULUCF)	298	29.2	25.7	25.2	25.1	25.1	24.7	24.7	24.2	23.3	22.8
HFCs	HFC-134a: 1,430 etc.	22.9	19.5	16.2	16.2	12.4	12.8	14.6	16.7	19.3	20.9
PFCs	PFC-14: 7,390 etc.	11.9	9.9	9.2	8.9	9.2	8.6	9.0	7.9	5.7	4.0
SF_6	22,800	7.0	6.1	5.7	5.4	5.3	5.1	5.2	4.7	4.2	2.4
NF_3	17,200	0.2	0.2	0.3	0.3	0.4	1.2	1.1	1.2	1.2	1.2
Gross total (excl. LULUCF)		1,386.7	1,358.7	1,390.3	1,392.7	1,389.6	1,397.1	1,377.9	1,412.8	1,327.2	1,251.0
Net total (incl. LULUCF)		1,299.9	1,271.8	1,301.8	1,294.7	1,294.2	1,307.2	1,293.4	1,330.3	1,255.7	1,184.4

[Million tonnes CO_2 eq.]	GWP	2010	2011	2012	2013	2014	Changes in emissions/removals (2014)	
							1990	Previous year
CO_2 (excl. LULUCF)	1	1,213.0	1,261.9	1,296.2	1,311.5	1,265.5	9.5%	-3.5%
CO_2 (incl. LULUCF)	1	1,143.6	1,192.3	1,223.4	1,246.2	1,203.8	9.8%	-3.4%
CO_2 (LULUCF only)	1	-69.4	-69.6	-72.8	-65.3	-61.7	3.5%	-5.5%
CH_4 (excl. LULUCF)	25	38.3	37.3	36.5	36.1	35.5	-27.0%	-1.6%
CH_4 (incl. LULUCF)	25	38.3	37.3	36.5	36.1	35.6	-26.9%	-1.6%
N_2O (excl. LULUCF)	298	22.3	21.8	21.4	21.5	20.8	-32.3%	-2.9%
N_2O (incl. LULUCF)	298	22.5	22.0	21.6	21.7	21.0	-32.3%	-2.9%
HFCs	HFC-134a: 1,430 etc.	23.3	26.1	29.3	32.1	35.8	124.6%	11.5%
PFCs	PFC-14: 7,390 etc.	4.2	3.8	3.4	3.3	3.4	-48.6%	2.5%
SF_6	22,800	2.4	2.2	2.2	2.1	2.1	-83.9%	-1.8%
NF_3	17,200	1.4	1.6	1.3	1.4	0.8	2425.8%	-39.0%
Gross total (excl. LULUCF)		1,304.9	1,354.6	1,390.3	1,407.9	1,363.9	7.3%	-3.1%
Net total (incl. LULUCF)		1,235.8	1,285.3	1,317.7	1,342.8	1,302.4	7.5%	-3.0%

* LULUCF: Land Use, Land-Use Change and Forestry

E.S.2.2. KP-LULUCF Activities

In accordance with the decision 2/CMP.8 in paragraph 4 adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP8), Japan reports afforestation/reforestation (AR), deforestation (D), forest management (FM), cropland management (CM), grazing land management (GM), and revegetation (RV) as LULUCF activities under article 3, paragraphs 3 and 4 of the Kyoto Protocol for the second commitment period[4]. The breakdown of emissions and removals for each activity is shown in Table 2. For detailed information, see Chapter 11.

Table 2 Accounting summary for activities under articles 3.3 and 3.4 of the Kyoto Protocol
(CRF Accounting table)

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year (1990)	NET EMISSIONS/REMOVALS	
		2013	2014
	(kt CO_2 eq)		
A. Article 3.3 activities			
A.1. Afforestation/reforestation		-532	-531
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
A.2. Deforestation		1493	2134
B. Article 3.4 activities			
B.1. Forest management			
Net emissions/removals		-51070	-50033
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
Any debits from newly established forest (CEF-ne)		NA	NA
Forest management reference level (FMRL)		0	0
Technical corrections to FMRL		1268	1489
Forest management cap			
B.2. Cropland management (if elected)	10262	3554	4328
B.3. Grazing land management (if elected)	841	-300	-90
B.4. Revegetation (if elected)	-79	-1206	-1225
B.5. Wetland drainage and rewetting (not elected)	NA	NA	NA

* The total values and results of summing up each element are not always the same because of the difference in display digit.

E.S.3. Overview of Source and Sink Category Emission Estimates and Trends

E.S.3.1. GHG Inventory

The breakdown of GHGs emissions and removals in FY2014 by sector[5] shows that the energy accounts for 89.1% of total GHGs emissions. It is followed by the industrial processes and product use (6.6%), the agriculture (2.8%), and the waste (1.6%).

Removals by the LULUCF in FY2014 were equivalent to 4.5% of total GHGs emissions.

[4] The emissions/removals occurring from Kyoto Protocol Article 3.3. and 3.4 activities correspond to a part of the LULUCF emission/removals reported under the Convention. Detailed information on LULUCF under the Convention can be found in chapter 6 of this report, and the same for KP-LULUCF activities can be found in chapter 11.

[5] As indicated in the *2006 IPCC Guidelines* and the CRF.

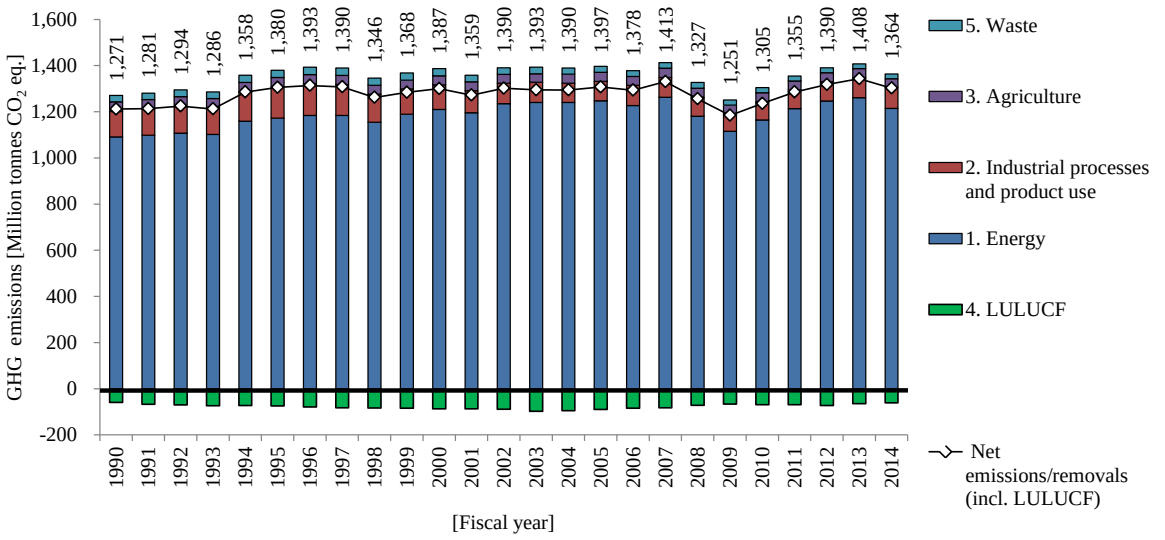


Figure 2 Trends in GHGs emissions and removals in each sector

Table 3 Trends in GHGs emissions and removals in each sector

[Million tonnes CO_2 eq.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy	1,091.2	1,098.4	1,107.2	1,101.4	1,158.7	1,172.0	1,183.8	1,183.7	1,154.4	1,189.4
2. Industrial processes and product use	109.3	113.7	115.5	117.7	125.0	135.1	137.1	134.1	121.5	108.7
3. Agriculture	42.0	40.7	42.4	37.9	43.2	41.3	40.5	40.0	38.2	38.6
4. LULUCF	-59.3	-67.5	-70.1	-73.9	-73.1	-74.7	-79.3	-82.6	-83.7	-84.2
5. Waste	28.2	28.1	29.3	28.8	31.3	31.5	31.7	32.1	31.7	31.2
Net emissions/removals (incl. LULUCF)	1,211.4	1,213.5	1,224.3	1,212.0	1,285.2	1,305.2	1,313.8	1,307.3	1,262.2	1,283.7
Emissions (excl. LULUCF)	1,270.7	1,280.9	1,294.4	1,285.9	1,358.3	1,379.9	1,393.1	1,389.9	1,345.8	1,367.9

[Million tonnes CO_2 eq.]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	1,209.8	1,195.4	1,234.9	1,240.5	1,240.0	1,247.0	1,226.8	1,262.2	1,180.1	1,115.2
2. Industrial processes and product use	106.6	95.5	88.5	87.1	83.8	84.8	87.4	86.5	82.2	74.9
3. Agriculture	39.2	38.6	38.8	37.3	38.9	39.2	38.8	40.0	39.4	38.6
4. LULUCF	-86.8	-86.9	-88.5	-98.0	-95.4	-89.9	-84.4	-82.5	-71.5	-66.6
5. Waste	31.0	29.2	28.1	27.8	26.9	26.1	24.8	24.1	25.4	22.2
Net emissions/removals (incl. LULUCF)	1,299.9	1,271.8	1,301.8	1,294.7	1,294.2	1,307.2	1,293.4	1,330.3	1,255.7	1,184.4
Emissions (excl. LULUCF)	1,386.7	1,358.7	1,390.3	1,392.7	1,389.6	1,397.1	1,377.9	1,412.8	1,327.2	1,251.0

[Million tonnes CO_2 eq.]	2010	2011	2012	2013	2014
1. Energy	1,164.4	1,213.6	1,246.9	1,260.6	1,214.7
2. Industrial processes and product use	78.4	80.2	82.8	87.0	89.6
3. Agriculture	39.9	39.4	38.9	38.8	38.4
4. LULUCF	-69.1	-69.3	-72.6	-65.0	-61.5
5. Waste	22.3	21.4	21.7	21.4	21.1
Net emissions/removals (incl. LULUCF)	1,235.8	1,285.3	1,317.7	1,342.8	1,302.4
Emissions (excl. LULUCF)	1,304.9	1,354.6	1,390.3	1,407.9	1,363.9

* LULUCF: Land Use, Land-Use Change and Forestry

E.S.3.2. KP-LULUCF Activities

See section 2.2 of this executive summary.

E.S.4. Other Information (Indirect GHGs and SO_X)

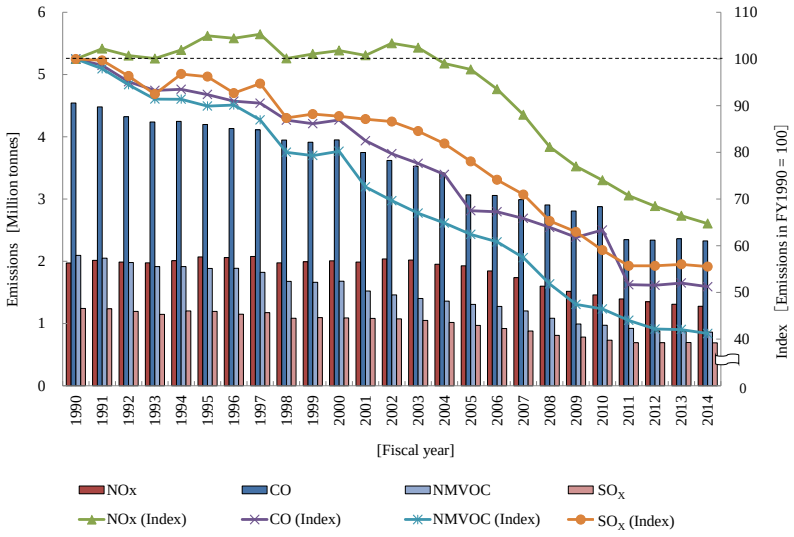
Under therevised UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (24/CP.19), it is required to report emissions not only 7 types of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6 and NF_3) that are controlled by the Kyoto Protocol, but also emissions of indirect GHGs (NO_X, CO and NMVOC) as well as SO_X. Their emission trends are indicated below.

Nitrogen oxide (NO_X) emissions in FY2014 were 1,277 thousand tonnes. They decreased by 35.3% since FY1990 and by 2.5% compared to the previous year.

Carbon monoxide (CO) emissions in FY2014 were 2,327 thousand tonnes. They decreased by 48.8% since FY1990 and decreased by 1.5% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY2014 were 863 thousand tonnes. They decrease by 58.8% since FY1990 and decreased by 2.0% compared to the previous year.

Sulfur oxide (SO_X)[6] emissions in FY2014 were 689 thousand tonnes. They decreased by 44.5% since FY1990 and decreased by 0.9% compared to the previous year.



(* The line chart shows the trend as an index of FY1990 emissions set at 100.)

Figure 3 Trends in emissions of indirect GHGs and SO_X

[6] Most SO_X consists of SO_2. For major sources, SO_2 emissions are estimated.

Chapter 1. Introduction

1.1. Background Information on Japan's Greenhouse Gas Inventory and Climate Change

Japan reports the greenhouse gas (GHG) inventories, which contain the information on emissions and removals of GHGs, including indirect GHGs and SO_2 in Japan from FY1990 to FY2014[1], on the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Decision 2/CMP.8.

Estimation methodologies for the GHG inventories are required to be in line with the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 IPCC Guidelines*), which was made by the Intergovernmental Panel on Climate Change (IPCC), and Japan's estimation methodologies are basically in line with these guidelines. In order to enhance transparency, consistency, comparability, completeness and accuracy of inventory, Japan also applies the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands (Wetlands Guidelines)* and *the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (KP Supplement (2013))*.

Japan's national inventory is reported in accordance with the *UNFCCC Reporting Guidelines on Annual Greenhouse Gas Inventories* (Decision 24/CP.19 Annex I, hereinafter referred to as the *UNFCCC Inventory Reporting Guidelines*) decided by the Conference of the Parties.

1.2. A Description of Japan's National Inventory Arrangements

1.2.1. Institutional, Legal and Procedural Arrangements

1.2.1.1. Institutional and legal Arrangement for the Inventory Preparation

The government of Japan is to calculate the emissions and removals of GHGs for Japan and disclose the results every year, in accordance with Article 7 of Chapter 1 General Provisions, the Act on Promotion of Global Warming Countermeasures[2], which determines the domestic measures for the UNFCCC and Kyoto Protocol. The Ministry of the Environment (MOE), with the cooperation of relevant ministries, agencies and organizations, prepares Japan's national inventory and compiles supplementary information required under Decision 2/CMP.8 etc, which is annually submitted in accordance with the UNFCCC and the Kyoto Protocol.

The MOE takes overall responsibilities for the national inventory and therefore makes every effort on improving the quality of inventory. The MOE organizes the "Committee for the Greenhouse Gas Emission Estimation Methods (Committee)" in order to integrate the latest scientific knowledge into the inventory and to modify it based on more recent international provisions. The estimation of GHG emissions and removals are then carried out by taking the decisions of the Committee into consideration. Substantial activities, such as the estimation of emissions and removals and the preparation of Common Reporting Formats (CRF) and National Inventory Report (NIR), are done by the Greenhouse Gas Inventory Office of Japan (GIO), which belongs to the Center for Global

[1] "FY (fiscal year)" is used because the major part of CO_2 emission estimate is on the fiscal year basis (April to March).
[2] Enacted in October, 1998. The latest amendment was made on May 30th, 2014.

Environmental Research of the National Institute for Environmental Studies. The relevant ministries, agencies and organizations provide the GIO the appropriate data (e.g., activity data, emission factors, GHG emissions and removals) through compiling various statistics and also provide relevant information on supplementary information required under Decision 2/CMP.8 etc. The relevant ministries and agencies check the inventories (i.e., CRF, NIR), including the spreadsheets that are actually utilized for the estimation (Japan National Greenhouse gas Inventory files, hereinafter referred to as JNGI files), as a part of the Quality Control (QC) activities.

The checked inventories are determined as Japan's official values. The inventories are then published by the MOE and are submitted to the UNFCCC Secretariat by the Ministry of Foreign Affairs.

Figure 1-1 shows the overall institutional arrangement for Japan's inventory preparation. More detailed information on the role and responsibility of relevant ministries, agencies and organizations in the inventory preparation process is described below.

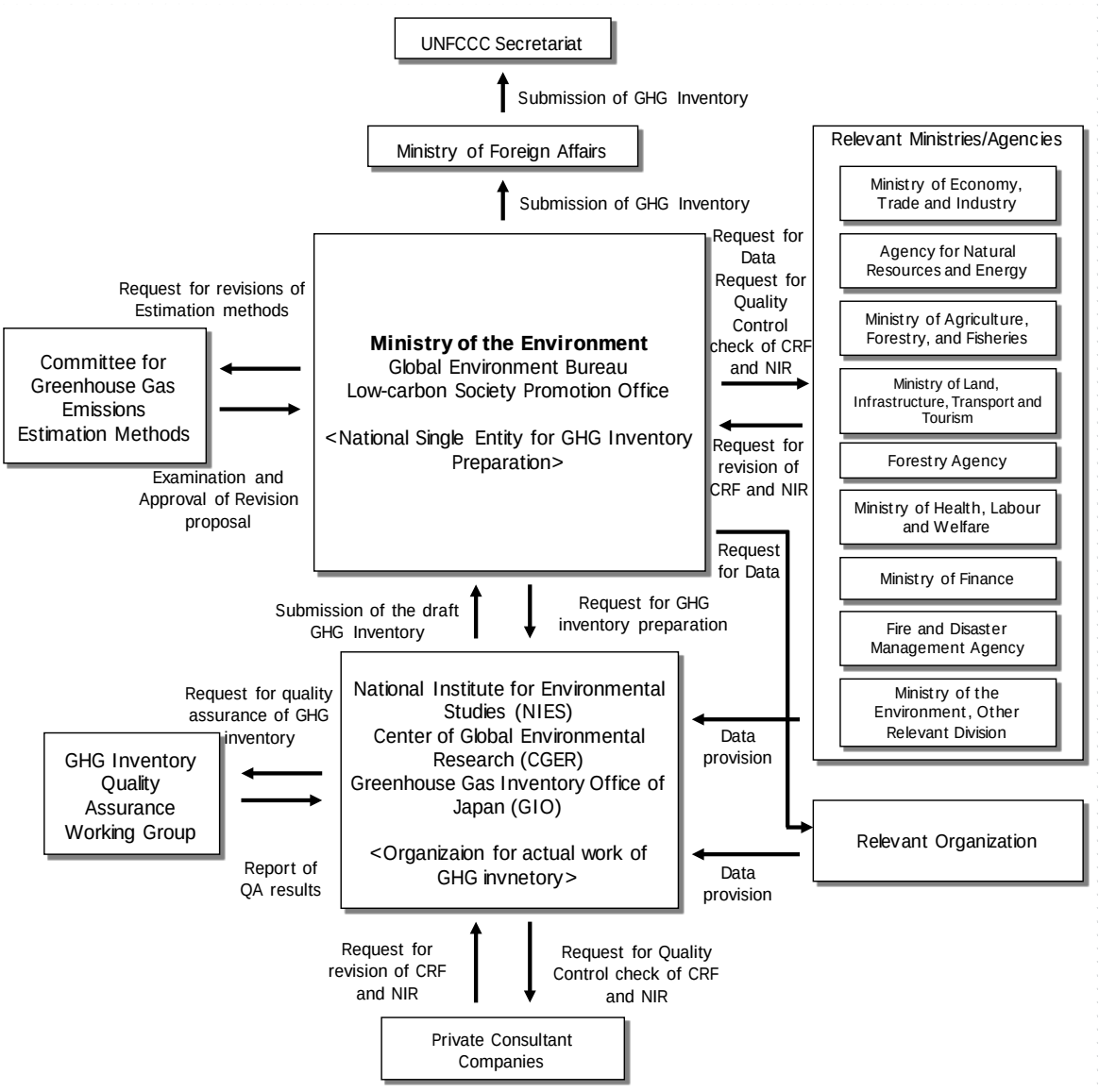


Figure 1-1 Japan's institutional arrangement for the national inventory preparation

1.2.1.2. Roles and responsibilities of each entity involved in the inventory preparation process

Following are the agencies involved in the inventory compilation process, and the roles of those agencies.

1) Ministry of the Environment (Low-carbon Society Promotion Office, Global Environment Bureau)

- The single national agency responsible for preparing Japan's inventory, which was designated pursuant to the UNFCCC Inventory Reporting Guidelines and the Kyoto Protocol Article 5.1.
- It is responsible for editing and submitting the inventory.
- It coordinates the QA/QC activities for the inventory.
- It prepares, confirms, and approves the QA/QC plan.
- It prepares, confirms, and approves the inventory improvement plan.

2) Greenhouse Gas Inventory Office of Japan (GIO), Center for Global Environmental Research, National Institute for Environmental Studies

- Performs the actual work of inventory compilation. Responsible for inventory calculations, editing, and the archiving and management of all data.

3) Relevant Ministries/Agencies

The relevant ministries and agencies have the following roles and responsibilities regarding inventory compilation.

- Confirmation of data provided for the preparation of the inventory.
- Confirmation of the inventory (CRF, NIR, JNGI files, and other information) (Category-specific QC) prepared by the GIO.
- (When necessary), responding to questions from expert review teams about the statistics controlled by relevant ministries and agencies, or about certain data they have prepared, and preparing comments on draft reviews.
- (When necessary), responding to visits by expert review teams.

4) Relevant Organizations

Relevant organizations have the following roles and responsibilities regarding inventory compilation.

- Confirmation of data provided for the preparation of the inventory.
- (When necessary), responding to questions from expert review teams about the statistics controlled by relevant organizations, or about certain data they have prepared, and preparing comments on draft reviews.

5) Committee for the Greenhouse Gas Emissions Estimation Methods

The Committee for the Greenhouse Gas Emissions Estimation Methods (Committee) is a committee created and run by the Ministry of the Environment. Its role is to consider the methods for calculating inventory emissions and removals, and consider the selection of parameters such as activity data and

emission factors. Under the Committee, the inventory working group (WG) that examines crosscutting issues, and breakout groups that consider sector-specific problems (Breakout group on Energy and Industrial Processes, Breakout group on Transport, Breakout group on F-gases [HFCs, PFCs, SF_6, and NF_3], Breakout group on Agriculture, Breakout group on Waste, and Breakout group on LULUCF) are set up. In addition, the Taskforce on NMVOC is set up as an additional sub-group under the Inventory WG, and the Taskforce examines methodologies of NMVOC emission estimation. The inventory WG, breakout groups and taskforce comprise experts in various fields, and consider suggestions for inventory improvements.

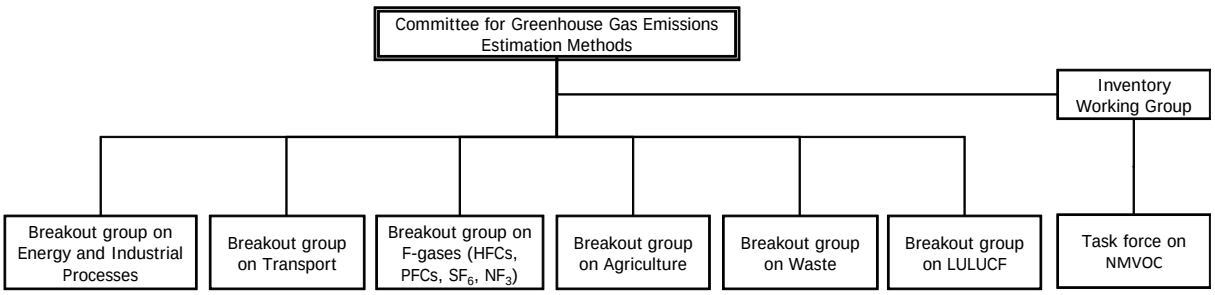


Figure 1-2 Structure of the Committee for the Greenhouse Gas Emissions Estimation Methods

6) Private Consulting Companies

Private consultant companies that are contracted by the Ministry of the Environment to perform tasks related to inventory compilation play the following roles in inventory compilation based on their contracts.

- Quality control (QC) of inventory (CRF, NIR, JNGI files, and other information) compiled by the Ministry of the Environment and the GIO.
- (When necessary), providing support for responding to questions from expert review teams and for preparing comments on draft reviews.
- (When necessary), providing support for responding to visits by expert review teams.

7) GHG Inventory Quality Assurance Working Group (Expert Peer Review) (QAWG)

The GHG Inventory Quality Assurance Working Group (the QAWG) is an organization that is for QA activities, and comprises experts who are not directly involved in inventory compilation. Its role is to assure inventory quality and to identify places that need improvement by conducting detailed reviews of each emission source and sink in the inventory.

1.2.1.3. Response for UNFCCC inventory review

The convention inventory and Kyoto Protocol supplementary information on sinks that Japan submits each year are to be reviewed by an expert review team (ERT) pursuant to UNFCCC inventory review guidelines[3], Kyoto Protocol Article 8, Decision 22/CMP.1, and other requirements. Specifically,

[3] Decision 13/CP.20 Annex

rigorous checks are performed in accordance with the designated guidelines[4] from perspectives including: whether emissions and removals are accurately and completely estimated and reported, or whether transparent explanations are provided for estimation methods, or whether QA/QC activities and uncertainty assessments are performed appropriately.

In view of the fact that ensuring the transparency of the inventory is a matter of importance, since Japan does not have a reduction commitment under the second commitment period of the Kyoto Protocol, the system shown in Figure 1-3 is used for responding to reviews.

The Ministry of the Environment, which in Japan is responsible for editing and submitting the inventory, is assigned to be the agency with overall control (responsibility) for review response, while the GIO performs the actual work, such as preparing source materials and communicating with the UNFCCC Secretariat. The relevant ministries and agencies, relevant organizations, and private consultant companies[5] that are involved in inventory compilation cooperate with review response through activities including providing relevant information, support for source material preparation, and QC implementation.

[4] UNFCCC Inventory Reporting Guidelines, *2006 IPCC Guidelines*, and the *KP Supplement (2013)*

[5] Private consultant companies cooperate in correspondence of the reviews based on the operating agreement with the Ministry of the Environment.

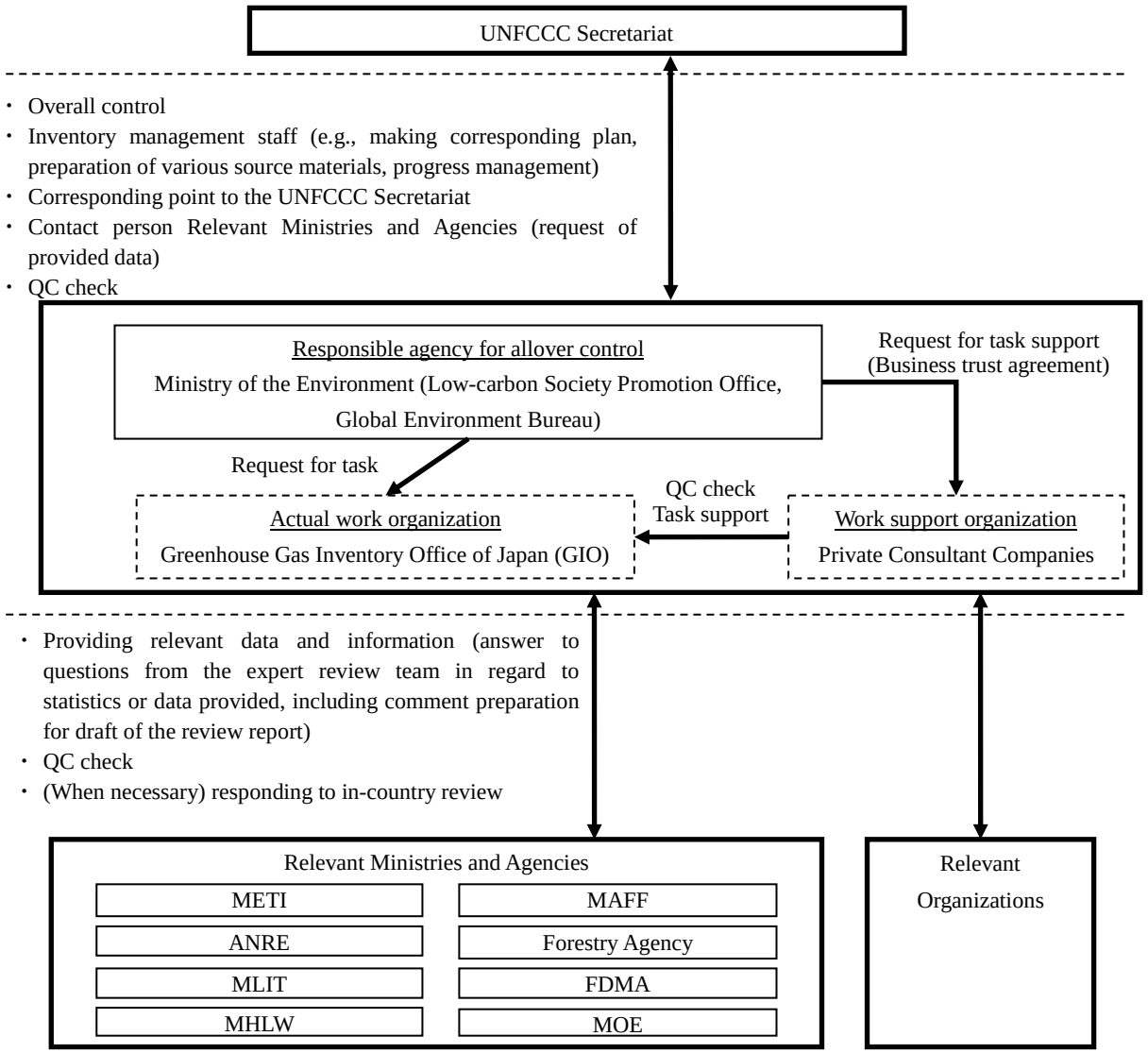


Figure 1-3 Basic structure of Japan's national system corresponding to inventory review

1.2.2. Overview of Inventory Planning, Preparation and Management

The Ministry of the Environment (Low-carbon Society Promotion Office, Global Environment Bureau) is the single national agency responsible for preparing Japan's inventory, and the Greenhouse Gas Inventory Office of Japan (GIO) performs the actual work of inventory compilation. Relevant ministries and organizations are also involved in the preparation of the inventory, mainly by preparing activity data, emission factor data, and other data needed for inventory compilation. Private consulting companies are contracted by MOE to perform tasks related to quality control (QC) of the inventory, mainly prepared by MOE and GIO.

The Committee for the Greenhouse Gas Emission Estimation Methods, run by MOE, considers the methods, activity data (AD) and emission factors (EFs) used. Under the Committee, the inventory working group (WG) that examines crosscutting issues, and breakout groups that consider sector-specific problems (Breakout group on Energy and Industrial Processes, Breakout group on Transport, Breakout group on F-gases, Breakout group on Agriculture, Breakout group on Waste, and Breakout group on LULUCF) are set up. In addition, the Taskforce on NMVOC is set up as an

additional sub-group under the Inventory WG, and the Taskforce examines methodologies of NMVOC emission estimation.

The emissions and removals are prepared in accordance with the UNFCCC Inventory Reporting Guidelines. (For details see sectoral chapters) The key category analysis is performed in accordance with the *2006 IPCC Guidelines*, and both Approach 1 and 2 are applied. (See section 1.5 for results) No additional key categories were identified using the qualitative approach. Key categories have been identified for activities under Article 3, paragraphs 3 and 4, of the Kyoto Protocol following the guidance on establishing the relationship between the activities under the Kyoto Protocol and the associated key categories in the UNFCCC inventory. The key category analysis is used to prioritize inventory improvements. The uncertainty analysis is carried out in accordance with the *2006 IPCC Guidelines*, and Approach 1 is applied. (See section 1.6 for results)

QC procedures are used in the inventory and are documented as part of the QA/QC plan. (See section 1.2.3 for details) As part of inventory quality assurance (QA), detailed reviews (expert peer reviews) are regularly performed by experts not directly involved in inventory compilation for each emission source and sink.

Japan has a centralized archiving system, which includes the archiving of disaggregated EFs and AD, and documentation on how these factors and data have been generated and aggregated for the preparation of the inventory. The archived information also includes internal documentation on QA/QC procedures, UNFCCC review and QA peer review, and documentation on annual key categories identification and planned inventory improvements. The archiving system is run by GIO and includes electronic and paper versions of documents.

1.2.3. Quality Assurance, Quality Control and Verification Plan

1.2.3.1. QA/QC Procedures Applied

When compiling the inventory in Japan, inventory quality is controlled by performing quality control (QC) activities (such as checking the correctness of calculations and archive of documents) at each step in accordance with *2006 IPCC Guidelines*. In Japan, the quality control activities relating to inventory compilation performed by personnel belonging to agencies involved in inventory compilation—that is, the Ministry of the Environment (including the GIO and private consultant companies), relevant ministries and agencies—are considered to be QC. External reviews by experts who are outside the inventory compilation system (QAWG) are considered to be QA (quality assurance). They assess data quality from the perspectives of scientific knowledge and data availability with respect to current calculation methods. Table 1-1 sketches Japan's QA/QC activities.

Table 1-1 Summary of Japan's QA/QC activity

	Implementing entity	Main contents of activity
QC (Quality Control)	Ministry of the Environment (Low-carbon Society Promotion Office, Global Environment Bureau)	・Coordinating QA/QC activities for inventory preparation ・Establishing, revising, and approving QA/QC plan ・Developing, checking, and approving inventory improvement plan
	Greenhouse Gas Inventory Office of Japan, Center for Global Environmental Research, National Institute for Environmental Studies (GIO)	・Conducting general QC check ・Archiving QA/QC activity records and relevant data and documents ・Developing inventory improvement plan ・Revising QA/QC plan
	Relevant Ministry and Agencies	・Checking data necessary for inventory preparation ・Checking JNGI files and inventory prepared by GIO (Category-specific QC)
	Committee for the Greenhouse Gas Emissions Estimation Methods	・Discussing and assessing estimation methods, emission factors, and activity data (Category-specific QC)
	Private Consultant Companies	・Checking JNGI files and inventory prepared by GIO (Category-specific QC)
QA (Quality Assurance)	Inventory Quality Assurance Working Group (QAWG)	・Conducting expert peer review of inventory (QA)

1.2.3.1.a. QC activity

a) General QC procedures

In accordance with Table 6.1, Chapter 6, Vol.1 of the *2006 IPCC Guidelines*, general QC procedures include the general items to be confirmed which are related to the calculation, data processing, completeness, and documentation applicable to all emission source and sink categories. General QC procedures are implemented by each inventory compiler.

Following are the QC activities conducted by the sectoral experts (SEs), who perform the work of compiling the emissions/removals estimation files for each category, the CRF master files and NIR; the National Inventory compiler (NIC), who integrates the information from the individual SEs and compiles the inventory; and the data providers, who provide the activity data and other data used to calculate emissions and removals.

This section describes the QC activities of the GIO and private consultant companies in parts 1) and 2).

1) Sectoral expert (SE)

SEs perform mainly the following QC activities.

- Checking for transcription errors in data entry and referencing
- Checking to ensure that emissions are accurately estimated
- Checking to see that parameters and emission units are accurately recorded, and that proper conversion factors are used
- Checking the conformity of databases and/or files
- Checking the consistency of data from one category to another
- Checking the accuracy of inventory data behavior from one processing step to the next
- Checking completeness
- Checking time series consistency
- Checking trends

- Conducting comparisons with past estimated values
- Checking that uncertainties in emissions and removals are accurately estimated and calculated
- Carrying out reviews of internal documentation
- Checking that the assumptions and criteria for selecting activity data and emission factors are documented

2) National inventory compiler (NIC)

The NIC performs mainly the following QC activities when preparing CRF files.

- Confirming that CRF Reporter data provided by SEs are imported without omission
- Confirming that the information needed for the documentation box is properly entered
- Confirming that the reasons for "NE" and "IE" are correctly entered
- Confirming that the key category analysis results are correctly entered
- Confirming that the reasons for recalculations are provided for all categories
- Confirming that emissions and removals are correctly aggregated
- Confirming that data are corrected after the coordination with the relevant ministries and agencies

b) QC procedure for source and sink each category

The following category-specific QC activities are performed in Japan:

1) QC by private consultant companies (External QC)

QC on the estimation files and CRF and NIR drafts prepared by the GIO, are performed by mutual checks of estimation results with private consultant companies, through the use of estimation files like those of the GIO, and confirming the data entered into estimation files for each source and sink category and the equations for calculating emissions and removal.

2) QC through coordination with the relevant ministries and agencies (External QC)

The relevant ministries and agencies are send the sets of files for estimation, CRF, NIR, and the drafts of published documents for domestic release showing estimated values for emissions and removals. Through this, category-specific QC is implemented for the content of categories relevant to each ministry or agency.

3) Committee for the Greenhouse Gas Emissions Estimation Methods

Since the Committee considers and selects the methodologies, activity data and parameters including emission factors, which are actually applied to the estimation of emissions/removals from each category, it also implements category-specific QC activities.

c) QC activities of the documentation and archiving of inventory information

GIO promptly implements QC activities of the documentation and archiving of inventory information, after the inventory submission to the UNFCCC.

1.2.3.1.b. QA activity

Quality assurance (QA) refers to assessment of inventory quality by third units that are not directly involved in inventory compilation. In Japan, the GHG Inventory Quality Assurance Working Group (Expert Peer Review) is held as a QA activity, to assure inventory quality.

a) GHG Inventory Quality Assurance Working Group (Expert Peer Review) (QAWG)

1) Summary

The QAWG performs detailed reviews (expert peer reviews) by experts not directly involved in inventory compilation for each emission source and sink in order to assure inventory quality and to identify places that need improvement.

2) Scope of review

The GHG Inventory Quality Assurance Working Group performs reviews mainly in the following areas, and utilizes the results for the preparation of the inventory for the next submission

- Confirming the soundness of estimation methods, activity data, emission factors, and other items.
- Confirming the soundness of content reported in the CRF and NIR.

3) Overview of QA/QC improvement activities

The QAWG fulfils QA activities for inventory preparation, reporting and reviewing as required for the Annex I Parties under the FCCC as well as the Kyoto Protocol by implementing a detailed review by experts, who are not directly involved in or related to the inventory preparation process, for each source and/or sink.

QA/QC activities as cross-cutting issues were reviewed by two experts in FY2013.

Results of review confirmed proper implementation of the QA/QC Plan as well as documenting and archiving information in the inventory preparation process. In the meantime, some issues requiring further consideration were raised.

Some of the issues identified by the review, including clarification of descriptions and additions of descriptions corresponding to already implemented activities that are currently not mentioned, will be addressed and reflected in the revised QA/QC and inventory process in this annual submission. Regarding the issues requiring further consideration, the secretariat will pursue consultations with concerned parties and strive to address and reflect them in the inventory process after the next year.

1.2.3.2. QA/QC Plan

The QA/QC Plan is an internal document that documents, among other things, the specifics of all QA/QC activities in all processes from the start of inventory compilation to the final report, the compilation schedule, and the apportionment of all involved entities' roles. It organizes and systematizes the QA/QC activities of inventory compilation and clarifies what each entity involved in compilation is supposed to do. Additionally, it is prepared for the purpose of guaranteeing the implementation of QA/QC activities.

The QA/QC Plan's scope includes the processes of preparing, reporting, and reviewing the inventory under the Framework Convention on Climate Change, and the supplementary information on sinks

under Kyoto Protocol Articles 3.3 and 3.4, as stipulated in Decision 2/CMP.8.

1.2.3.3. Verification Activities

Confirmation such as the following have been undertaken in the Breakout groups of the Committee for the Greenhouse Gas Emission Estimation Methods: checking the appropriateness of emission factors which were established based on actual measurements in the past, against new measurements, or checking the appropriateness of applying specific emission factors based on models, to the national inventory. Additionally, the inventory emissions are checked against entity-based emission data reported under the Mandatory GHG Accounting and Reporting System - a system that aims to reduce emissions from entities by requiring them to estimate and understand the amount of GHG emissions originating from their own activities. This mutual verification activity is to avoid any possible large omission of emissions.

1.2.3.4. Treatment of Confidential Information

Part of the activity data and emission factors, other parameters, and emissions obtained from ministries or the private sector correspond to confidential information. These are listed and archived. At the stage of obtaining and archiving data, and in the QC process, data is protected by using a password, and confidential files are distinguished from others, together with restricted access. When sending data to relevant ministries for checks, confidential data are sent only to the ministry which provided the data. At the stage of UN reporting, a minimum level of aggregation with other sub-categories is performed, and the notation key “C” (confidential) is used.

1.2.4. Changes in the National Inventory Arrangements since the Previous Annual GHG Inventory Submission

In line with paragraph 50 (J) of the UNFCCC Inventory Reporting Guidelines and paragraph 21 of the annex to decision 15/CMP.1, Japan reports the changes in its national inventory arrangements from the previous inventory submission.

1.3. Inventory Preparation, and Data Collection, Processing and Storage

1.3.1. Annual cycle of the inventory preparation

Table 1-2 shows the annual cycle of the inventory preparation. The inventory preparation cycle is set in conjunction with Japan's fiscal year calendar (starting April 1st and ending March 31 the next year) In Japan, in advance of the estimation of national inventory submitted to the UNFCCC (submission deadline: 15th April), preliminary figures are estimated and published as a document for an official announcement. (In preliminary figures, only GHG emissions excluding removals are estimated.)

Table 1-2 Annual cycle of the inventory preparation

*Inventory preparation in fiscal yaer "n"

	Process	Relevant Entities	Calender Year n+1								CY n+2			
			Fiscal Year n+1											FY n+2
			May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1	Discussion on the inventory improvement	MOE, GIO		→	→	→	→							
2	Holding the meeting of the Committee	MOE, (GIO, Private consultant)		→	→	→	→	→	→	→	→			
3	Collection of data for the national inventory	MOE, GIO, Relevant Ministries/Agencies, Relevant organization, Private consultant								→	→	→	→	
4	Preparation of a draft of CRF	GIO, Private consultant									→	→	→	
5	Preparation of a draft of NIR	GIO, Private consultant									→	→	→	
6	Implementation of the exterior QC and the coordination with the relevant ministries and agencies	MOE, GIO, Relevant Ministries/Agencies, Private consultant										→	→	→
7	Correction of the drafts of CRF and NIR	MOE, GIO, Private consultant											→	→
8	Submission and official announcement of the national inventory	MOE, Ministry of Foreign Affairs, GIO												★
9	Holding the meeting of the QA-WG	MOE, GIO	→	→	→	→								

MOE: Ministry of the Environment
GIO: Greenhouse Gas Inventory Office of Japan
Committee: Committee for the Greenhouse Gas Emission Estimation Methods
QAWG: Inventory Quality Assurance Working Group

1.3.2. Process of the inventory preparation

1) Discussion on the inventory improvement (Step 1)

The MOE and the GIO identify the items, which need to be addressed by the Committee, based on the results of the previous inventory review of the UNFCCC, the recommendations of the “Inventory Quality Assurance Working Group (QAWG)”, the items needing improvement as identified at former Committee’s meetings, as well as any other items, requiring revision, as determined during previous inventory preparations. The schedule for the expert evaluation (step 2) is developed by taking the above mentioned information into account.

2) Holding the meeting of the Committee for the Greenhouse Gas Emission Estimation Methods [evaluation and examination of estimation methods by experts] (Step 2)

The MOE holds the meeting of the Committee, in which estimation methodologies for an annual inventory and the issues that require technical reviews are discussed by experts with different scientific backgrounds.

3) Collection of data for the national inventory (Step 3)

The data required for preparing the national inventory and the supplementary information required under Decision 2/CMP.8 are collected.

4) Preparation of a draft of CRF [including the implementation of the key category analysis and the uncertainty assessment] (Step 4)

The data input and estimation of emissions and removals are carried out simultaneously by utilizing JNGI files, which have inter-connecting links among themselves based on the calculation formulas for emissions and removals. Subsequently, the key category analysis and the uncertainty assessment are also carried out.

5) Preparation of a draft of NIR (Step 5)

The draft of NIR is prepared by following the general guidelines made by the MOE and the GIO. The MOE and the GIO identify the points, which need to be revised or require an additional description by

taking the discussion at step 1 into account. The GIO and the selected private consulting companies prepare new NIR by updating data, and by adding and revising descriptions in the previous NIR.

6) Implementation of the external QC and the coordination with the relevant ministries and agencies (Step 6)

As a QC activity, the selected private consulting companies check the JNGI files and the initial draft of CRF (the 0^{th} draft) prepared by the GIO (external QC). The companies not only check the input data and the calculation formulas in the files, but also check the estimations by re-calculating the total amounts of GHG emissions and removals determined by utilizing the same files. Because of this cross-check, any possible data input and emission estimation mistakes are avoided. They also check the content and descriptions of the initial draft of NIR (the 0^{th} draft) prepared by the GIO. JNGI files, draft CRF and draft NIR, which have been checked by the private consulting companies, are regarded as the primary drafts of inventories.

Subsequently, the GIO sends out the primary drafts of the inventories and official announcements as electronic computer files to the MOE and the relevant ministries and agencies, and requests them to check contents of the primary drafts. The data, which are estimated based on confidential data, are only sent out for confirmation to the ministry and/or agency which provided these confidential data.

7) Correction of the drafts of CRF and NIR (Step 7)

When revisions are requested as a result of the check of the primary drafts of the inventories and official announcements by the relevant ministries and agencies (step 6), the MOE, GIO and relevant ministries and/or agencies that submit requests of revision coordinate contents of revision and then revise the primary drafts and prepare the secondary drafts. The secondary drafts are sent out again to the relevant ministries and/or agencies for conclusive confirmation. If there is no additional request for revision, the secondary drafts are considered to be the final versions.

8) Submission and official announcement of the national inventory (Step 8)

The MOE submitted the completed inventory to the Ministry of Foreign Affairs, and the Ministry of Foreign Affairs submitted the inventory to the UNFCCC Secretariat. At the same time of the submission, information on the estimated GHG emissions and removals are officially announced and published on the MOE's homepage (http://www.env.go.jp/) with additional relevant information. The inventory is also published on the GIO's homepage (http://www-gio.nies.go.jp/index-j.html).

9) Holding the meeting of the Greenhouse Gas Inventory Quality Assurance Working Group (Step 9)

The QAWG, which is composed of experts who are not directly involved in or related to the inventory preparation process, is organized in order to perform peer review and assure the inventory's quality and to find out possible improvements.

This QAWG reviews the appropriateness of the estimation methodologies, activity data, emission factors, and the contents of CRF and NIR. GIO integrates the items identified for improvement by the QAWG into the inventory improvement plan, and utilizes them in discussions on the inventory estimation methods and in subsequent inventory preparation.

1.3.3. Documentation and Archiving of Inventory Information

In Japan, the information needed for inventory compilation is documented and as a rule archived by the agency which compiles the inventory (GIO).

The main files (all JNGI files, NIR word files, and CRFs) needed for inventory compilation is electronically archived at MOE as well.

1.3.3.1. Documentation of information

The GIO documents all the inventory-related information in electronic or printed form and archives it. Examples of information that must be archived follow.

- The inventory related files submitted every year to the UNFCCC Secretariat
- Published materials for preliminary and finalized data
- Statistical data and provided data (including data providers, time period when provided, and other related information) used in compiling the inventory
- Information on the discussion process and discussion results related to the selection of activity data, estimation methods, emission factors, and other items (relevant source materials for the discussion process by the Committee for the Greenhouse Gas Emissions Estimation Methods)
- Records of communications with related entities in the inventory compilation process
- Information on inventory recalculations (such as reasons for recalculations, and when performed)
- QA/QC Plan and records of QA/QC activities conducted, including holding the QAWG
- Comments by experts on the inventory
- In relation to UNFCCC inventory reviews, review reports and records of questions and answers with expert review teams

1.3.3.2. Archiving of information

1) Archiving electronic information

ⅰ) Inventory-related electronic information

- Each year's JNGI files and CRF- and NIR-related files have file names with the year the estimation is for and the year it was performed, and files are saved in folders prescribed for each year.
- Electronic files of statistical data, provided data, etc. used to prepare the inventory's emissions/removals estimates and other, related data are given file names with the date on which the data were obtained and the data provider, and saved in prescribed folders.
- Source materials in electronic form (files in Word, PDF, or other format) used when considering emissions/removals estimation methods are labeled with the source material title and the date the file was obtained (and if necessary the file provider), and saved in prescribed folders.
- If the exchange of information on the inventory has been conducted by email, the email files are saved in prescribed folders.

ⅱ) Backup and risk management of electronic information

- The CGER server, where inventory-related information is stored, is automatically backed up to two other locations every day.

- Once a year, after submission of the annual inventory to the UNFCCC Secretariat, all inventory-related electronic information is saved to CD-ROMs and other electronic media and archived.

2) Archiving printed form

- Books of statistics, data and source materials (including faxes) in printed form that have been provided, and other source materials in printed form that have been used in inventory emissions/removals estimates are filed in a prescribed storage location.

1.3.3.3. QC activity for documentation and archiving of inventory information

Immediately after the inventory is submitted to the UNFCCC Secretariat, the GIO carries out QC activities related to the documentation and archive of inventory information.

1.4. Brief General Description of Methodologies and Data Sources Used (including tiers used)

The methodology used in estimation of GHG emissions or removals is basically in accordance with the *2006 IPCC Guidelines*. The country-specific methodologies are also used for some source/sink categories in order to more accurately reflect the actual emission status in Japan.

Results of the actual measurements or estimates based on research conducted in Japan are used to determine the emissions factors (country-specific emissions factors). The default values given in the *2006 IPCC Guidelines* are used for estimation of emissions, which are assumed to be quite low (e.g., "1.B.2.a.ii fugitive emissions from fuel (oil and natural gas" (CO_2 and CH_4))) etc.

1.4.1. Collection Process of Activity Data

When the activity data needed for calculations are available from sources such as publications and the internet, the necessary data are gathered from these media. Data that are not released in publications, the internet, or in other media, and unpublished data that are used when compiling the inventory are obtained by the Ministry of the Environment or the GIO by requesting them from the relevant ministries and agencies and the relevant organizations which control those data. This system manages all the information related to provision of data. The main relevant ministries, agencies, and relevant organizations, and their statistics and data are as shown in Table 1-3.

Table 1-3 Main relevant ministries, agencies, and the relevant organizations, and their statistics and data

Ministries/Agencies/Organizations		Major data or statistics
Relevant Ministries/ Agencies	Ministry of the Environment	Research of Air Pollutant Emissions from Stationary Sources/ Waste Treatment in Japan/ Report of the research on the state of wide-range movement and cyclical use of wastes (the volume on cyclical use)/ Survey of Industrial Waste Treatment Facilities
	Ministry of Economy, Trade and Industry	General Energy Statistics / Yearbook of Chemical Industry Statistics / Yearbook of Ceramics and Building Materials Statistics/ Amount of nitric acid production/ Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub -Group, Industrial Structure Council
	Ministry of Land, Infrastructure, Transport and Tourism	Statistical Yearbook of Motor Vehicle Fuel Consumption / Survey on Current State of Land Use, Survey on Current State of Urban Park Development
	Ministry of Agriculture, Forestry and Fisheries	Livestock Statistics / Statistics of Arable and Planted Land Area / Yearbook of Fertilizer Statistics (Pocket Edition)/ Forest Status Survey/ National Forest Resources Database
Relevant Organizations	Federation of Electric Power Companies	Amount of Fuel Used by Pressurized Fluidized Bed Boilers
	Japan Coal Energy Center	Coal Production/ History of Coal Policy
	Japan Cement Association	Amount of clinker production / Cement Handbook
	Japan Iron and Steel Federation	Emissions from Coke Oven Covers, Desulfurization Towers, and Desulfurization Recycling Towers
	Japan Paper Association	Amount of final disposal of industrial waste / Amount of RPF incineration

1.4.2. Selection Process of Emission Factors and Estimation Methods

Calculation methods for Japan's emission and removal amounts are determined by having the Committee explore calculation methods suited to Japan's situation for all the activity categories necessary for calculating Japan's greenhouse gas emission and removal amounts, based on the *2006 IPCC Guidelines*.

1.4.3. Improvement Process of Estimations for Emissions and Removal

In Japan, improvements in calculation methods are considered in accordance with necessity whenever an inventory item requiring improvement is identified because of, for example, a UNFCCC review or an observation by the QAWG, progress in international negotiations such as the creation of new guidelines, progress or changes in scientific research or in the compilation of statistics, or the acquisition of new information by the system for calculating, reporting, and publishing GHG emissions. Proposals for improving the estimation of emissions and removals are considered by scientific research or the Committee, and the results are incorporated into the inventory. Figure 1-4 is a diagram of the inventory improvement process.

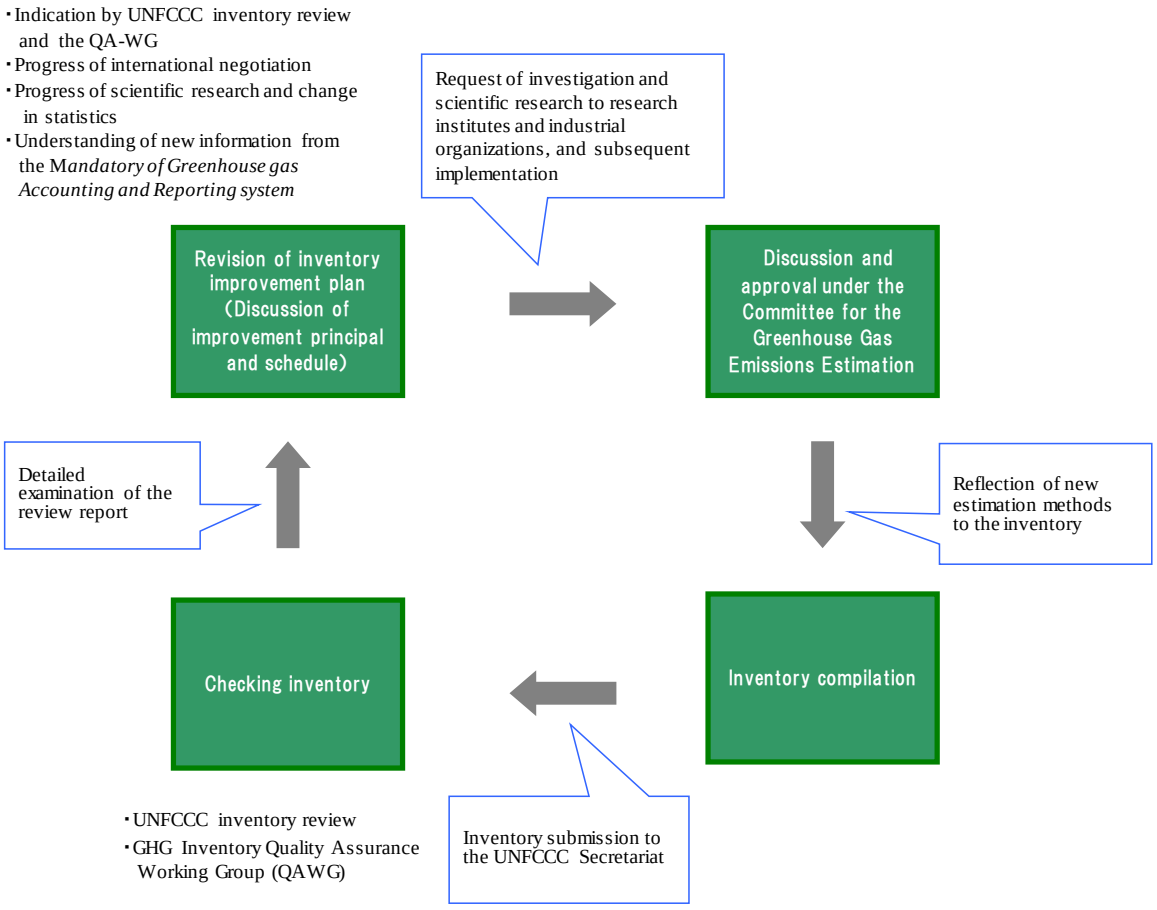


Figure 1-4 Diagram of the inventory improvement process

1.5. Brief Description of Key Categories

Key category analysis is carried out in accordance with the *2006 IPCC Guidelines* and the *KP Supplement (2013)* (Approach 1, Approach 2 level assessment and trend assessment).

1.5.1. GHG Inventory

In FY2014, 47 sources and sinks were identified as Japan's key categories (Table 1-4). For the base year of the UNFCCC (FY1990), 40 sources and sinks were identified as key categories (Table 1-5). More detailed information is described in Annex 1.

Table 1-4 Japan's key categories in FY2014

	Category Code			B GHGs	Ap1-L	Ap1-T	Ap2-L	Ap2-T
#1	A-02	1.A.1. Energy Industries	Solid Fuels	CO2	#1	#1	#1	#2
#2	A-08	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	#2	#12	#3	#28
#3	A-16	1.A.3. Transport	b. Road Transportation	CO2	#3		#4	
#4	A-03	1.A.1. Energy Industries	Gaseous Fuels	CO2	#4	#2	#12	#14
#5	A-01	1.A.1. Energy Industries	Liquid Fuels	CO2	#5	#4	#8	#8
#6	A-25	1.A.4. Other Sectors	Liquid Fuels	CO2	#6	#5	#9	#16
#7	A-07	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	#7	#3	#13	#6
#8	D-01	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	#8	#10	#2	#7
#9	A-27	1.A.4. Other Sectors	Gaseous Fuels	CO2	#9	#8	#32	
#10	A-09	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	#10	#7		#29
#11	B-26	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	#11	#6	#7	#4
#12	B-01	2.A Mineral Product	1. Cement Production	CO2	#12	#11	#21	#20
#13	C-04	3.C Rice Cultivation		CH4	#13		#23	
#14	E-04	5.C Incineration and Open Burning of Waste		CO2	#14		#10	
#15	A-22	1.A.3. Transport	d. Domestic Navigation	CO2	#15	#21		
#16	A-13	1.A.3. Transport	a. Domestic Aviation	CO2	#16			
#17	A-10	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	#17	#17	#16	#17
#18	C-01	3.A Enteric Fermentation		CH4	#18		#11	#19
#19	A-04	1.A.1. Energy Industries	Other Fossil Fuels	CO2	#19		#24	
#20	C-03	3.B Manure Management		N2O			#5	
#21	D-03	4.B Cropland	1. Cropland remaining Cropland	CO2		#16	#15	#5
#22	C-05	3.D Agricultural Soils	1. Direct Emissions	N2O			#26	#24
#23	E-01	5.A Solid Waste Disposal		CH4		#15	#28	#10
#24	B-06	2.B Chemical Industry	Other products except Anmonia	CO2			#14	#21
#25	A-06	1.A.1. Energy Industries		N2O			#27	#22
#26	B-27	2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs			#18	#12
#27	C-02	3.B Manure Management		CH4			#34	
#28	C-06	3.D Agricultural Soils	2. Indirect Emissions	N2O			#6	#13
#29	A-12	1.A.2. Manufacturing Industries and Construction		N2O			#30	
#30	D-11	4.E Settlements	1. Settlements remaining Settlements	CO2			#31	
#31	B-23	2.E Electronics Industry		PFCs			#17	
#32	E-07	5.D Wastewater Treatment and Discharge		CH4				#27
#33	B-31	2.F Product uses as substitutes for ODS	5. Solvents	PFCs		#22		#26
#34	A-18	1.A.3. Transport	b. Road Transportation	N2O			#25	#9
#35	B-34	2.G Other Product Manufacture and Use		SF6		#13	#19	#1
#36	E-06	5.C Incineration and Open Burning of Waste		N2O			#22	
#37	D-12	4.E Settlements	2. Land converted to Settlements	CO2		#19		#15
#38	E-08	5.D Wastewater Treatment and Discharge		N2O			#29	
#39	A-32	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4		#18		#3
#40	B-09	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O			#33	#11
#41	B-24	2.E Electronics Industry		SF6			#20	
#42	D-02	4.A Forest Land	2. Land converted to Forest Land	CO2				#31
#43	D-04	4.B Cropland	2. Land converted to Cropland	CO2				#23
#44	D-14	4.F Other Land	2. Land converted to Other Land	CO2				#30
#45	B-08	2.B Chemical Industry	3. Adipic Acid Production	N2O		#14		#18
#46	B-10	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs		#9		#25
#47	B-12	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	SF6		#20		

N.B.1) Ap1-L: Approach 1-Level Assessment, Ap1-T: Approach 1-Trend Assessment,
Ap2-L: Approach 2-Level Assessment, Ap2-T: Approach 2-Trend Assessment
N.B.2) Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 1-5 Japan's key categories in FY1990

	A IPCC Category		B GHGs	Ap1-L	Ap2-L
#1	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	#1	#2
#2	1.A.3. Transport	b. Road Transportation	CO2	#2	#4
#3	1.A.1. Energy Industries	Liquid Fuels	CO2	#3	#6
#4	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	#4	#7
#5	1.A.4. Other Sectors	Liquid Fuels	CO2	#5	#12
#6	1.A.1. Energy Industries	Solid Fuels	CO2	#6	#11
#7	1.A.1. Energy Industries	Gaseous Fuels	CO2	#7	#27
#8	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	#8	#1
#9	2.A Mineral Product	1. Cement Production	CO2	#9	#19
#10	1.A.4. Other Sectors	Gaseous Fuels	CO2	#10	
#11	3.C Rice Cultivation		CH4	#11	#25
#12	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	#12	
#13	1.A.3. Transport	d. Domestic Navigation	CO2	#13	
#14	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	#14	
#15	5.C Incineration and Open Burning of Waste		CO2	#15	#17
#16	4.B Cropland	1. Cropland remaining Cropland	CO2	#16	#9
#17	5.A Solid Waste Disposal		CH4	#17	#15
#18	3.A Enteric Fermentation		CH4	#18	#14
#19	2.G Other Product Manufacture and Use		SF6	#19	#3
#20	2.C Metal Production	1 Iron and Steel Production	CO2	#20	
#21	2.B Chemical Industry	3. Adipic Acid Production	N2O	#21	#29
#22	1.A.3. Transport	a. Domestic Aviation	CO2	#22	
#23	1.A.1. Energy Industries	Other Fossil Fuels	CO2	#23	#26
#24	2.A Mineral Product	2. Lime Production	CO2	#24	
#25	1.A.4. Other Sectors	Solid Fuels	CO2	#25	
#26	4.E Settlements	2. Land converted to Settlements	CO2	#26	#24
#27	3.D Agricultural Soils	1. Direct Emissions	N2O	#27	#20
#28	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4		#10
#29	3.B Manure Management		N2O		#8
#30	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2		#30
#31	2.B Chemical Industry	Other products except Anmonia	CO2		#16
#32	1.A.3. Transport	b. Road Transportation	N2O		#13
#33	3.B Manure Management		CH4		#32
#34	5.D Wastewater Treatment and Discharge		CH4		#31
#35	3.D Agricultural Soils	2. Indirect Emissions	N2O		#5
#36	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O		#18
#37	2.E Electronics Industry		PFCs		#22
#38	5.C Incineration and Open Burning of Waste		N2O		#23
#39	5.D Wastewater Treatment and Discharge		N2O		#28
#40	2.E Electronics Industry		SF6		#21

N.B.1) Ap1-L: Approach 1-Level Assessment, Ap2-L: Approach 2-Level Assessment
N.B.2) Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

1.5.2. KP-LULUCF Activity

As a result of analysis implemented in accordance with the *2006 IPCC Guidelines* and the *KP Supplement (2013)*, "Afforestation/Reforestation", "Deforestation", "Forest management", "Cropland management", and "Revegetation" activities (CO_2) were identified as key categories for Japan's KP-LULUCF activities in FY2014. More detailed information is described in section 11.8 of chapter 11.

1.6. General Uncertainty Assessment, including Data on the Overall Uncertainty for the Inventory Totals

1.6.1. GHG Inventory

Total net GHG emissions in Japan for FY2014 were approximately 1,302 million tonnes (CO_2

equivalents). The total net emissions uncertainties calculated by approach 1 (propagation of error) were -2% to +2% and the uncertainties introduced into the trend in the total emissions were -3% to +2%. More detailed information on the uncertainty assessment is described in Annex 2.

Table 1-6 Uncertainty of Japan's GHG inventory

A	B	C	D	G-1990		G-2014		I	J	
Category	Gas	Base year emissions / removals	2014 emissions / removals	Combined uncertainty in 1990		Combined uncertainty in 2014		Inventory trend in national emissions for 2014 increase with respect to 1990	Uncertainty introduced into the trend in total national emissions	
		kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(+) %	%	(-) %	(+) %
1A. Fuel Combustion (CO_2)	CO_2	1,078,082	1,205,408	-2%	+1%	-2%	+1%	11.8%	-2.6%	+1.7%
1A. Fuel Combustion (Stationary:CH_4,N_2O)	CH_4, N_2O	3,958	6,196	-28%	+30%	-29%	+30%	56.5%	0.0%	+0.0%
1A. Fuel Combustion (Transport:CH_4,N_2O)	CH_4, N_2O	4,031	1,861	-32%	+92%	-29%	+86%	-53.8%	0.0%	+0.0%
1B. Fugitive Emissions from Fuels	CO_2, CH_4, N_2O	5,165	1,233	-40%	+83%	-23%	+42%	-76.1%	0.0%	+0.0%
2. IPPU (CO_2,CH_4,N_2O)	CO_2, CH_4, N_2O	73,955	47,608	-4%	+4%	-4%	+4%	-35.6%	-0.1%	+0.1%
2. IPPU (HFCs,PFCs,SF_6,NF_3)	HFCs, PFCs, SF_6, NF_3	35,355	42,042	-7%	+33%	-7%	+9%	18.9%	-0.4%	+0.4%
3. Agriculture	CO_2, CH_4, N_2O	41,998	38,372	-9%	+22%	-8%	+20%	-8.6%	0.0%	+0.0%
4. LULUCF	CO_2, CH_4, N_2O	-59,295	-61,463	-17%	+17%	-13%	+13%	3.7%	-0.4%	+0.4%
5. Waste	CO_2, CH_4, N_2O	28,200	21,142	-11%	+11%	-11%	+12%	-25.0%	-0.2%	+0.2%
Total Net Emissions		1,211,448	1,302,399	-+2.2%	+1.9%	-+1.9%	+1.5%	7.5%	-2.6%	+1.8%

1.6.2. KP-LULUCF Activity

Japan's net removals in FY2014 were 45.4 million tonnes (CO_2 equivalents) and the uncertainty was 16%. More detailed information on the uncertainty assessment is described in section 11.5.1.7 of chapter 11.

Table 1-7 Uncertainty of Japan's KP-LULUCF activities

Greenhouse gas source and sink activities	GHGs	Emissions/Removals [kt CO_2eq.]		Emissions/Removals Uncertainty [%]		Emissions/Removals Uncertainty as % of net removals [%]	
			%	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.3 activities Afforestation and Reforestation	CO_2, N_2O, CH_4	-531	-1%	-33%	33%	0%	0%
Article 3.3 activities Deforestation	CO_2, N_2O, CH_4	2,134	5%	-19%	19%	1%	-1%
Article 3.4 activities Forest management	CO_2, N_2O, CH_4	-50,033	-110%	-14%	14%	-16%	16%
Article 3.4 activities Cropland management	CO_2, N_2O, CH_4	4,328	10%	-33%	33%	3%	-3%
Article 3.4 activities Grazing land management	CO_2, N_2O, CH_4	-90	0%	-15%	15%	0%	0%
Article 3.4 activities Revegetation	CO_2, N_2O, CH_4	-1,225	-3%	-33%	33%	-1%	1%
Total		-45,417	-100%	-16%	16%		

1.7. General Assessment of the Completeness

In this inventory report, emissions from some categories are not estimated and reported as "NE".

Source categories reported as NE in this year's report include those whose emissions are thought to be very small, those whose emissions are unknown, and those for which emission estimation methods have not been developed. For these categories, further investigation on their emission possibility and the development of estimation methodologies will be carried out in accordance with Japan's QA/QC plan. See Annex 5 for a list of not-estimated emission source categories.

- ***Impacts of the Great East Japan Earthquake***

  In order to check impacts of the Great East Japan Earthquake, which occurred on 11th March, 2011, on completeness, accuracy and consistency of activity data, we carried out investigations by questionnaires and hearing to all of the relevant ministries, agencies and organizations which are responsible for management of statistics used in estimation of GHG emissions and removals. As a result, we confirmed that the impacts of the Great East Japan Earthquake on the statistics, including missing data in them, were insignificant in the total emissions and removals. Since the inventory was prepared after experts' assessment and review of estimation methodologies, etc. taking into account the investigation results, completeness, accuracy and consistency of the inventory are considered to be assured. However, for some statistical data, investigation and checks on the data continued since the impacts of the earthquake on the data were still insufficient. Based on the ongoing investigation results, GHG emissions from wastes and refuses due to disaster are reported in Chapter 7 (waste sector).

Chapter 2. Trends in GHGs Emissions and Removals

2.1. Description and Interpretation of Emission and Removal Trends for Aggregate GHGs

2.1.1. Overview of GHGs Emissions and Removals

Total GHGs emissions in FY2014[1,2] (excluding LULUCF[3]) were 1,364 million tonnes (in CO_2 eq.). They increased by 7.3% compared to the emissions in FY1990 (excluding LULUCF).

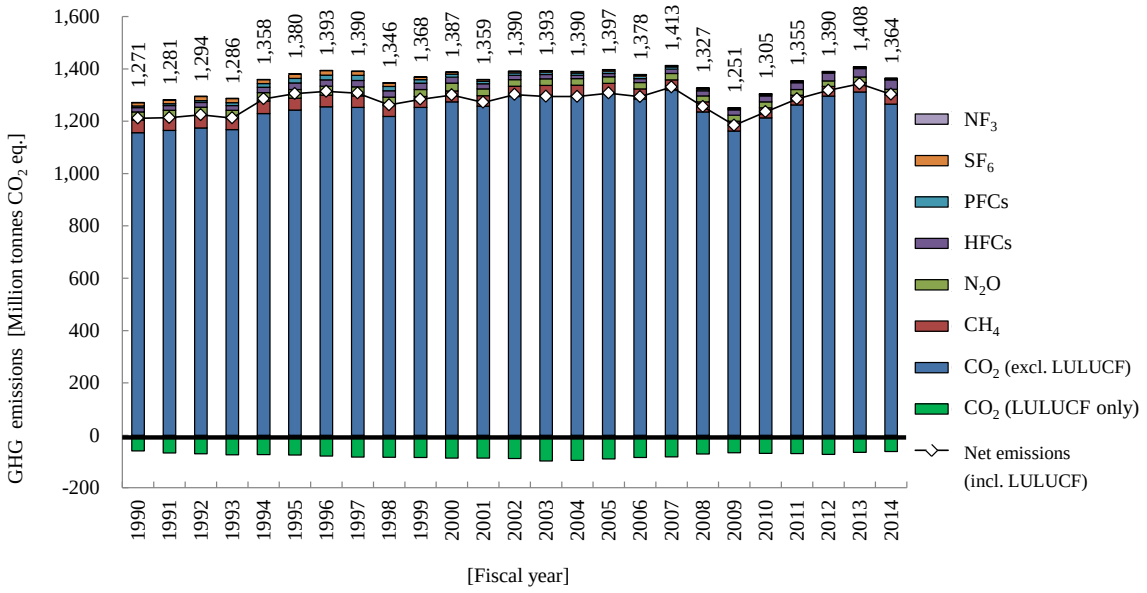


Figure 2-1 Trends in GHG emissions and removals in Japan

Carbon dioxide emissions in FY2014 were 1,265 million tonnes (excluding LULUCF), accounting for 92.8% of total GHGs emissions. They increased by 9.5% since FY1990 and decreased by 3.5% compared to the previous year. Carbon dioxide removals[4] in FY2014 were 61.7 million tonnes, which were equivalent to 4.5% of total GHGs emissions. They increased by 3.5% since FY1990 and decreased by 5.5% compared to the previous year. Methane emissions in FY2014 (excluding LULUCF) were 35.5 million tonnes (in CO_2 eq.), accounting for 2.6% of total GHGs emissions. They decreased by 27.0% since FY1990 and by 1.6% compared to the previous year. Nitrous oxide emissions in FY2014 (excluding LULUCF) were 20.8 million tonnes (in CO_2 eq.), accounting for 1.5% of total GHGs emissions. They decreased by 32.3% since FY1990 and by 2.9% compared to the previous year.

[1] "FY" (fiscal year), from April of the reporting year through March of the next year, is used because CO_2 is the primary GHGs emissions and estimated on a fiscal year basis. "CY" stands for calendar year.

[2] The sum of CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3 emissions converted to CO_2 equivalents, multiplied by their respective global warming potential (GWP). The GWP is a coefficient by means of which greenhouse gas effects of a given gas are made relative to those of an equivalent amount of CO_2. The coefficients are subjected to the *Fourth Assessment Report* (2007) issued by the Intergovernmental Panel on Climate Change (IPCC).

[3] Abbreviation of "Land Use, Land-Use Change and Forestry"

[4] Since the inventory to be submitted under the UNFCCC reports all GHG emissions and removals from the LULUCF sector, these values do not correspond to emissions and removals under the Kyoto Protocol.

Hydrofluorocarbons emissions in CY2014 were 35.8 million tonnes (in CO_2 eq.), accounting for 2.6% of total GHGs emissions. They increased by 124.6% since CY1990 and by 11.5% compared to the previous year. Perfluorocarbons emissions in CY2014 were 3.4 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 48.6% since CY1990 and increased by 2.5% compared to the previous year. Sulfur hexafluoride emissions in CY2014 were 2.1 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 83.9% since CY1990 and by 1.8% compared to the previous year. Nitrogen trifluoride emissions in CY2014 were 0.8 million tonnes (in CO_2 eq.), accounting for 0.1% of total GHGs emissions. They increased by a factor of 25 since CY1990 and decreased by 39.0% compared to the previous year.

Table 2-1 Trends in GHG emissions and removals in Japan

[Million tonnes CO_2 eq.]	GWP	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (excl. LULUCF)	1	1,156.0	1,164.5	1,174.6	1,167.7	1,228.9	1,242.5	1,255.3	1,253.1	1,218.3	1,253.1
CO_2 (incl. LULUCF)	1	1,096.4	1,096.7	1,104.2	1,093.5	1,155.5	1,167.5	1,175.7	1,170.2	1,134.3	1,168.6
CO_2 (LULUCF only)	1	-59.6	-67.8	-70.4	-74.2	-73.4	-75.0	-79.6	-82.9	-84.0	-84.4
CH_4 (excl. LULUCF)	25	48.6	46.9	48.1	42.8	47.9	45.8	44.5	43.7	41.4	41.4
CH_4 (incl. LULUCF)	25	48.7	46.9	48.1	42.9	48.0	45.9	44.6	43.8	41.4	41.5
N_2O (excl. LULUCF)	298	30.8	30.5	30.6	30.5	31.8	32.2	33.3	34.1	32.5	26.4
N_2O (incl. LULUCF)	298	31.1	30.7	30.9	30.8	32.1	32.4	33.5	34.3	32.7	26.6
HFCs	HFC-134a: 1,430 etc.	15.9	17.3	17.8	18.1	21.1	25.2	24.6	24.4	23.7	24.4
PFCs	PFC-14: 7,390 etc.	6.5	7.5	7.6	10.9	13.4	17.6	18.3	20.0	16.6	13.1
SF_6	22,800	12.9	14.2	15.6	15.7	15.0	16.4	17.0	14.5	13.2	9.2
NF_3	17,200	0.03	0.03	0.03	0.04	0.1	0.2	0.2	0.2	0.2	0.3
Gross total (excl. LULUCF)		1,270.7	1,280.9	1,294.4	1,285.9	1,358.3	1,379.9	1,393.1	1,389.9	1,345.8	1,367.9
Net total (incl. LULUCF)		1,211.4	1,213.5	1,224.3	1,212.0	1,285.2	1,305.2	1,313.8	1,307.3	1,262.2	1,283.7

[Million tonnes CO_2 eq.]	GWP	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (excl. LULUCF)	1	1,274.3	1,257.4	1,294.4	1,299.5	1,298.4	1,305.9	1,285.2	1,319.8	1,235.5	1,162.6
CO_2 (incl. LULUCF)	1	1,187.2	1,170.2	1,205.6	1,201.3	1,202.8	1,215.7	1,200.5	1,237.1	1,163.7	1,095.7
CO_2 (LULUCF only)	1	-87.1	-87.2	-88.8	-98.2	-95.6	-90.2	-84.7	-82.7	-71.7	-66.9
CH_4 (excl. LULUCF)	25	41.5	40.2	39.5	37.6	39.0	38.9	38.2	38.5	38.2	37.2
CH_4 (incl. LULUCF)	25	41.5	40.3	39.6	37.6	39.1	39.0	38.3	38.5	38.3	37.2
N_2O (excl. LULUCF)	298	29.0	25.5	25.0	24.9	24.9	24.5	24.5	24.0	23.1	22.6
N_2O (incl. LULUCF)	298	29.2	25.7	25.2	25.1	25.1	24.7	24.7	24.2	23.3	22.8
HFCs	HFC-134a: 1,430 etc.	22.9	19.5	16.2	16.2	12.4	12.8	14.6	16.7	19.3	20.9
PFCs	PFC-14: 7,390 etc.	11.9	9.9	9.2	8.9	9.2	8.6	9.0	7.9	5.7	4.0
SF_6	22,800	7.0	6.1	5.7	5.4	5.3	5.1	5.2	4.7	4.2	2.4
NF_3	17,200	0.2	0.2	0.3	0.3	0.4	1.2	1.1	1.2	1.2	1.2
Gross total (excl. LULUCF)		1,386.7	1,358.7	1,390.3	1,392.7	1,389.6	1,397.1	1,377.9	1,412.8	1,327.2	1,251.0
Net total (incl. LULUCF)		1,299.9	1,271.8	1,301.8	1,294.7	1,294.2	1,307.2	1,293.4	1,330.3	1,255.7	1,184.4

[Million tonnes CO_2 eq.]	GWP	2010	2011	2012	2013	2014	Changes in emissions/removals (2014)	
							1990	Previous year
CO_2 (excl. LULUCF)	1	1,213.0	1,261.9	1,296.2	1,311.5	1,265.5	9.5%	-3.5%
CO_2 (incl. LULUCF)	1	1,143.6	1,192.3	1,223.4	1,246.2	1,203.8	9.8%	-3.4%
CO_2 (LULUCF only)	1	-69.4	-69.6	-72.8	-65.3	-61.7	3.5%	-5.5%
CH_4 (excl. LULUCF)	25	38.3	37.3	36.5	36.1	35.5	-27.0%	-1.6%
CH_4 (incl. LULUCF)	25	38.3	37.3	36.5	36.1	35.6	-26.9%	-1.6%
N_2O (excl. LULUCF)	298	22.3	21.8	21.4	21.5	20.8	-32.3%	-2.9%
N_2O (incl. LULUCF)	298	22.5	22.0	21.6	21.7	21.0	-32.3%	-2.9%
HFCs	HFC-134a: 1,430 etc.	23.3	26.1	29.3	32.1	35.8	124.6%	11.5%
PFCs	PFC-14: 7,390 etc.	4.2	3.8	3.4	3.3	3.4	-48.6%	2.5%
SF_6	22,800	2.4	2.2	2.2	2.1	2.1	-83.9%	-1.8%
NF_3	17,200	1.4	1.6	1.3	1.4	0.8	2425.8%	-39.0%
Gross total (excl. LULUCF)		1,304.9	1,354.6	1,390.3	1,407.9	1,363.9	7.3%	-3.1%
Net total (incl. LULUCF)		1,235.8	1,285.3	1,317.7	1,342.8	1,302.4	7.5%	-3.0%

* LULUCF: Land Use, Land-Use Change and Forestry

2.1.2. CO_2

Carbon dioxide emissions in FY2014 were 1,265 million tonnes (excluding LULUCF), accounting for 92.8% of total GHGs emissions. They increased by 9.5% since FY1990 and decreased by 3.5% compared to the previous year.

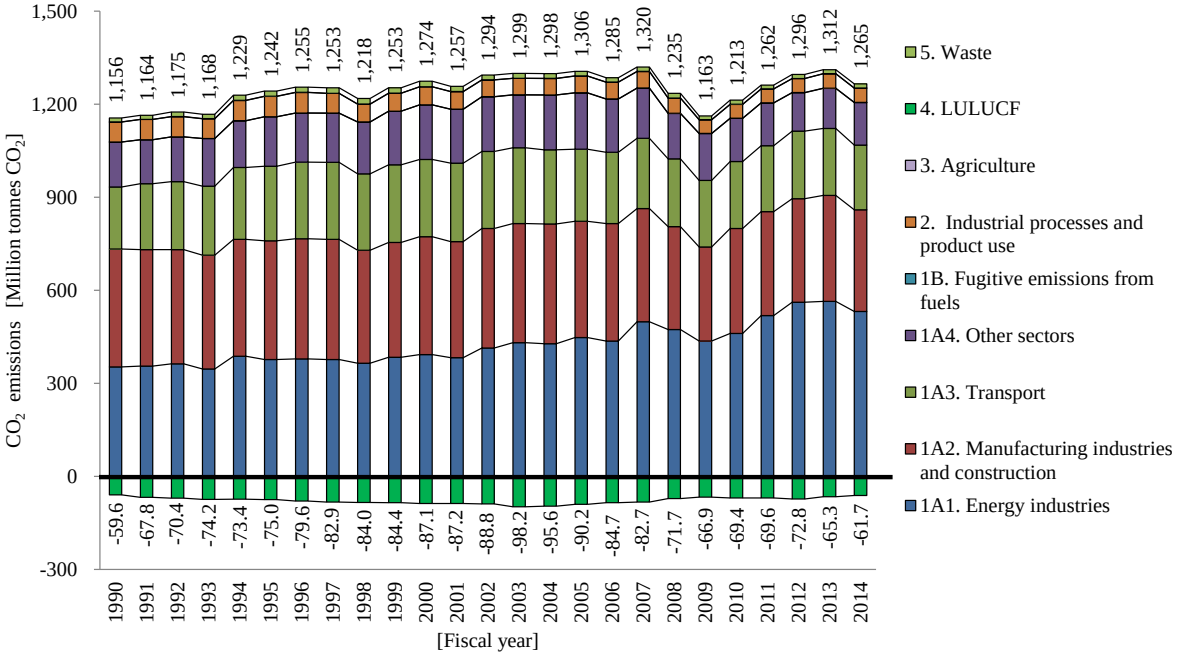


Figure 2-2 Trends in CO_2 emissions

The breakdown of CO_2 emissions in FY2014 shows that fuel combustion accounts for 95.3%, and is followed by industrial processes and product use (3.6%) and waste sectors (1.0%). As for the breakdown of CO_2 emissions within the fuel combustion category, energy industries accounts for 42.0% and is followed by manufacturing industries and construction at 25.9%, transport at 16.5%, and other sectors[5] at 10.8%. The main driving factor for the decrease in CO_2 emissions compared to the previous year is the CO_2 emissions from electricity power generation in the energy industries sector.

By looking at the changes in emissions by sector, emissions from fuel combustion in the energy industries increased by 50.7% since FY1990 and decreased by 5.8% compared to the previous year. The main driving factor for the increase compared to the emissions in FY1990 is the increased solid fuel consumption for electricity power generation. Emissions from manufacturing industries and construction decreased by 13.7% since FY1990 and decreased by 4.0% compared to the previous year. Emissions from transport increased by 4.0% compared to FY1990 and decreased by 3.5% compared to the previous year. The main driving factor for the increase compared to the emissions in FY1990 is the increase in emissions from passenger vehicles, compensating for the decrease in emissions from freight transportation. Emissions from other sectors decreased by 5.3% since FY1990 and increased by 6.1% compared to the previous year.

[5] It covers emissions from commercial/institutional, residential and agriculture/forestry/fishing.

Carbon dioxide removals in FY2014 were 61.7 million tonnes, which were equivalent to 4.5% of total GHGs emissions. They increased by 3.5% since FY1990 and decreased by 5.5% compared to the previous year.

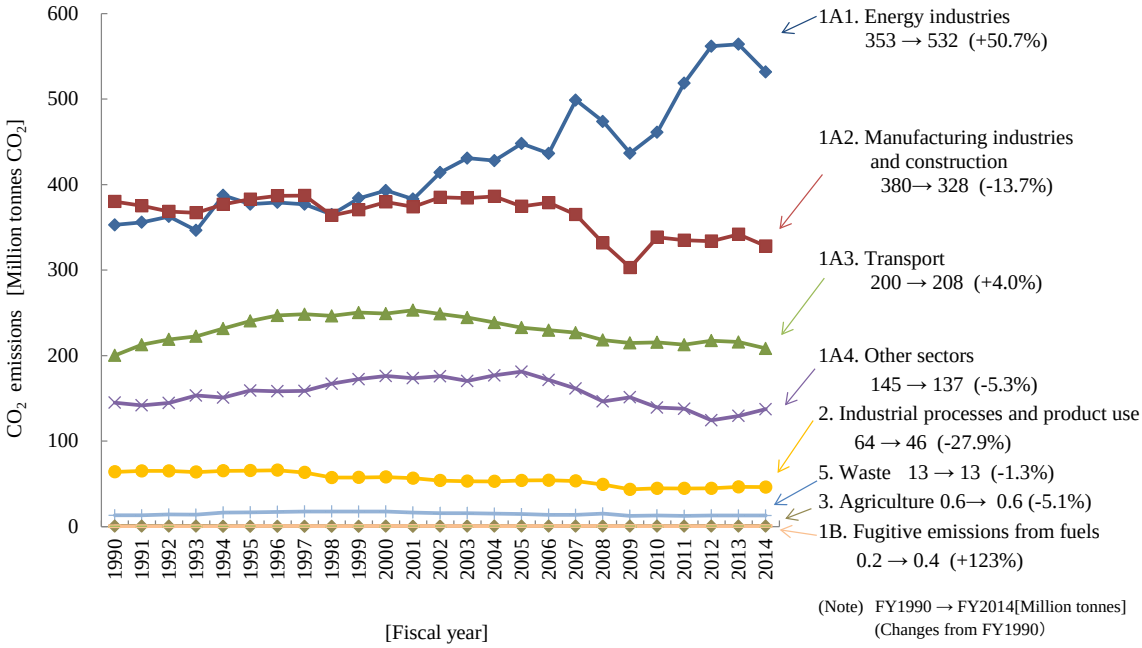


Figure 2-3 Trends in CO_2 emissions in each sector

(Figures in brackets indicate relative increase or decrease to the FY1990 values)

Table 2-2 Trends in CO_2 emissions and removals in each sector

[Thousand tonnes CO_2]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1A. Fuel combustion	1,078,082	1,159,452	1,197,784	1,236,463	1,216,394	1,251,734	1,170,017	1,105,649	1,154,339	1,203,959	1,237,398	1,251,180	1,205,408
1A1. Energy industries	352,783	377,029	393,060	447,943	436,483	498,753	473,840	436,771	461,180	518,613	561,886	564,189	531,711
Public electricity and heat production	300,173	318,716	334,091	382,780	374,112	428,021	399,444	360,396	383,263	444,486	490,975	495,608	470,325
Petroleum refining	37,150	41,766	47,377	50,884	49,775	48,426	46,987	47,307	49,627	46,429	45,144	47,454	41,973
Manufacture of solid fuels and other energy industries	15,460	16,546	11,592	14,279	12,596	22,305	27,409	29,067	28,290	27,698	25,767	21,128	19,414
1A2. Manufacturing industries and construction	380,111	382,862	379,660	374,577	378,733	364,799	331,642	302,927	338,406	334,848	333,748	341,762	328,151
Iron and steel	167,331	155,182	163,244	172,177	179,462	173,629	148,781	139,438	159,485	153,689	159,085	164,755	168,836
Non-ferrous metals	8,409	7,080	5,536	5,389	5,640	5,536	4,942	4,389	3,073	3,177	3,159	3,398	2,998
Chemicals	63,684	73,044	65,825	59,926	59,299	58,858	54,003	55,790	55,741	54,606	52,242	57,061	53,952
Pulp, paper and print	28,247	33,041	32,272	30,010	29,233	28,117	25,707	23,538	24,011	25,056	23,262	25,030	22,629
Food processing, beverages and tobacco	17,039	19,828	23,810	25,905	24,862	23,003	23,887	17,666	24,818	24,494	23,298	17,813	14,611
Non-metallic minerals	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other	95,401	94,687	88,974	81,171	80,237	75,656	74,323	62,106	71,279	73,826	72,702	73,705	65,126
1A3. Transport	200,215	240,453	249,014	232,727	229,663	226,722	218,193	214,764	215,467	212,651	217,436	215,803	208,287
Domestic aviation	7,162	10,278	10,677	10,799	11,178	10,876	10,277	9,781	9,193	9,001	9,524	10,149	10,172
Road transportation	178,442	214,684	222,613	208,267	205,124	203,061	196,002	193,931	194,956	192,661	196,765	194,172	186,582
Railways	935	822	711	647	623	594	604	590	574	555	554	540	540
Domestic navigation	13,675	14,669	15,012	13,014	12,739	12,191	11,310	10,462	10,745	10,434	10,594	10,942	10,993
1A4. Other sectors	144,973	159,108	176,049	181,216	171,515	161,459	146,342	151,187	139,285	137,847	124,327	129,425	137,258
Commercial/institutional	80,186	86,868	102,040	109,061	103,365	94,445	83,597	89,123	73,851	74,603	61,620	69,342	79,535
Residential	58,366	68,310	71,037	69,614	65,479	64,553	60,897	59,611	62,883	60,670	60,039	57,660	55,497
Agriculture/forestry/fishing	6,421	3,931	2,972	2,540	2,671	2,461	1,847	2,453	2,551	2,574	2,669	2,423	2,226
1A5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B. Fugitive emissions from fuels	192	521	512	508	553	616	565	501	475	477	490	438	426
1C. CO_2 transport and storage	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
2. Industrial processes and product use	63,984	65,452	57,918	53,955	54,083	53,297	49,170	43,514	44,684	44,544	44,732	46,387	46,116
3. Agriculture	609	359	443	411	383	500	440	390	403	415	520	578	578
4. LULUCF	-59,607	-74,978	-87,093	-90,204	-84,696	-82,707	-71,749	-66,894	-69,367	-69,581	-72,831	-65,286	-61,722
5. Waste	13,127	16,709	17,642	14,603	13,764	13,653	15,263	12,553	13,070	12,468	13,046	12,927	12,963
Total (including LULUCF)	1,096,387	1,167,516	1,187,205	1,215,735	1,200,482	1,237,093	1,163,707	1,095,712	1,143,603	1,192,282	1,223,355	1,246,223	1,203,768
Total (excluding LULUCF)	1,155,994	1,242,494	1,274,298	1,305,939	1,285,178	1,319,799	1,235,456	1,162,606	1,212,970	1,261,863	1,296,186	1,311,509	1,265,491

* LULUCF: Land Use, Land-Use Change and Forestry

Carbon dioxide emissions (excluding LULUCF) per capita in FY2014 were 9.96 tonnes. They increased by 6.5% since FY1990 and decreased by 3.3% compared to the previous year.

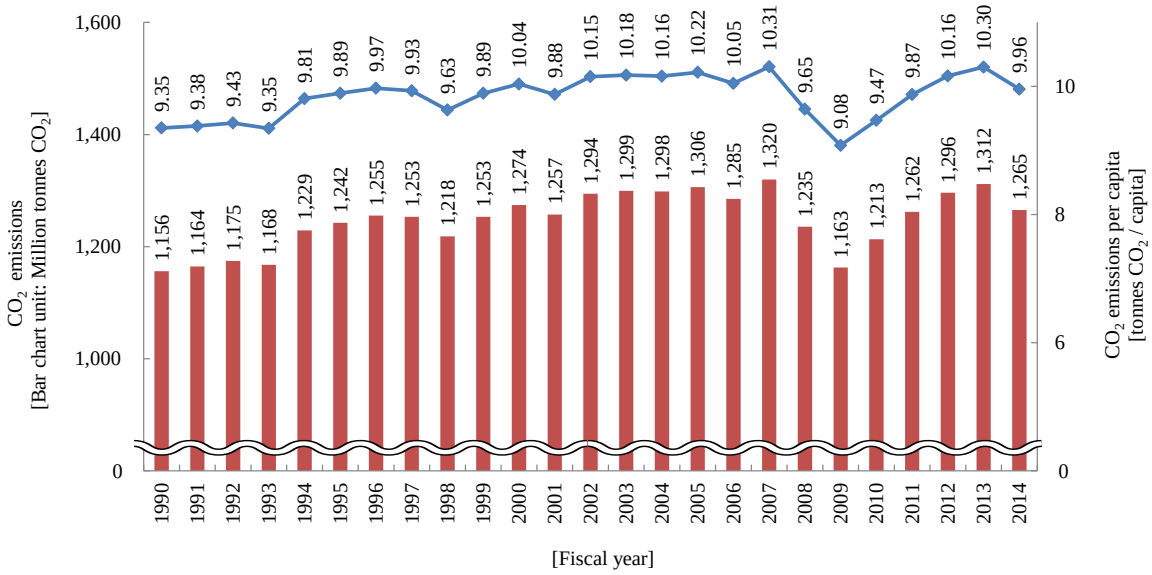


Figure 2-4 Trends in total CO_2 emissions and CO_2 emissions per capita

Source of population data: Ministry of Internal Affairs and Communications, Statistics Bureau, Population Census and Annual Report of Population Estimates

Carbon dioxide emissions per unit of GDP (million yen) in FY2014 were 2.41 tonnes. They decreased by 10.3% since FY1990 and decreased by 2.6% compared to the previous year.

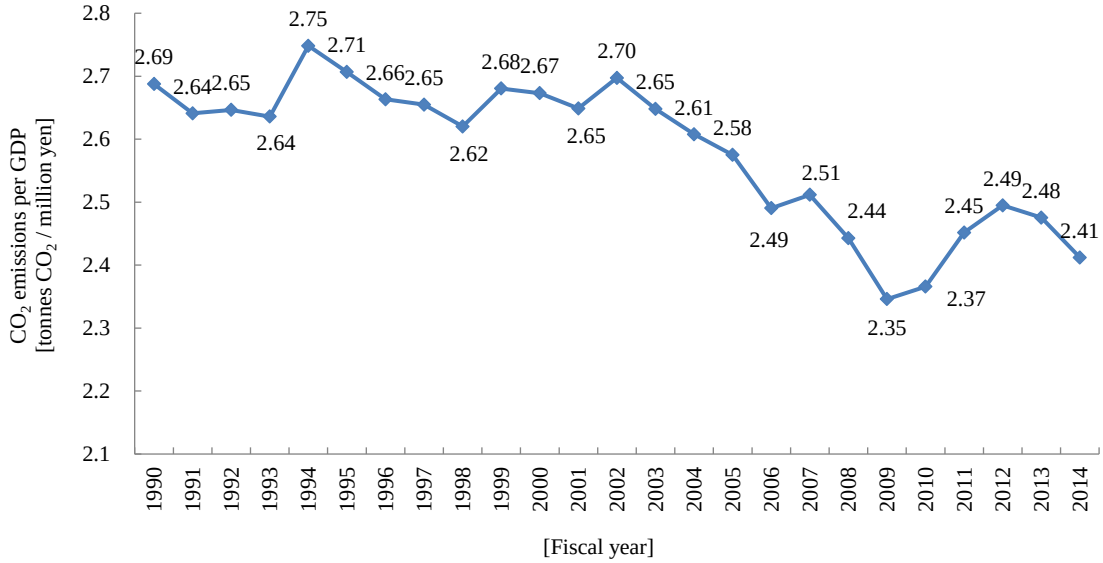


Figure 2-5 Trends in CO_2 emissions per unit of GDP

Source of GDP data: Cabinet Office, Government of Japan, *Annual Report on National Accounts*

2.1.3. CH_4

Methane emissions in FY2014 were 35.6 million tonnes (in CO_2 eq., including LULUCF), accounting for 2.6% of total GHGs emissions. They decreased by 26.9% since FY1990 and by 1.6% compared to the previous year. Their decrease since FY1990 is mainly a result of a 56.3% decrease in emissions from the waste sector (solid waste disposal).

Breakdown of the FY2014 emissions shows that the largest source is rice cultivation accounting for 50%. It is followed by enteric fermentation (20%) and solid waste disposal (9%).

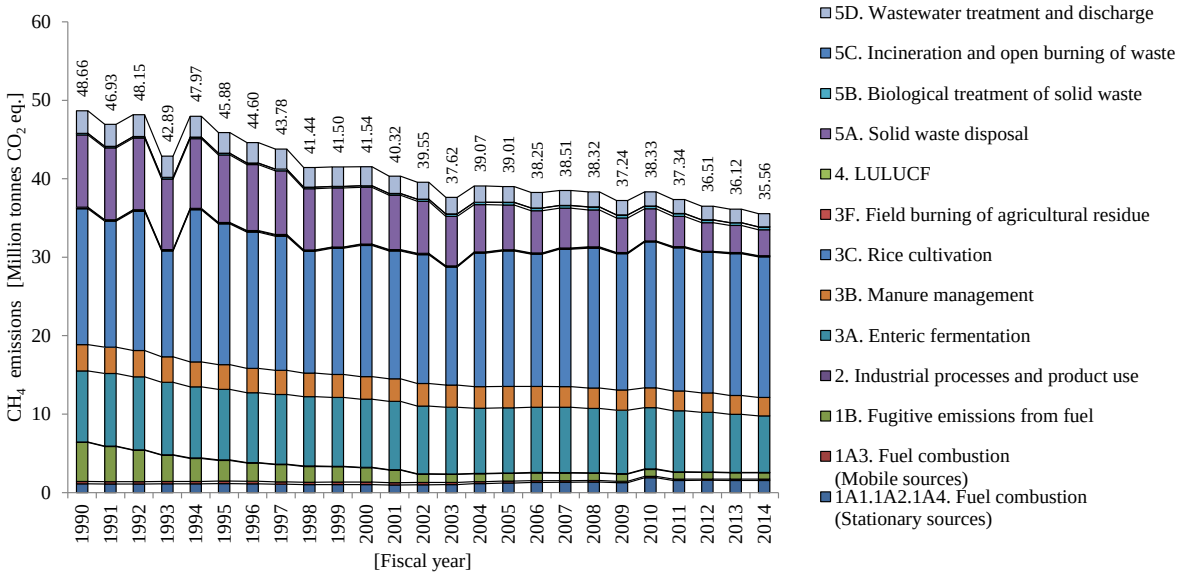


Figure 2-6 Trends in CH_4 emissions

Table 2-3 Trends in CH_4 emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1A. Fuel combustion	1,419	1,460	1,336	1,473	1,523	1,529	1,533	1,451	2,071	1,719	1,729	1,708	1,707
1A1. Energy industries	431	403	256	214	216	247	316	313	348	370	397	324	299
1A2. Manufacturing industries and construction	441	437	427	522	569	576	551	546	600	480	495	510	519
1A3. Transport	291	309	312	247	232	219	200	186	178	169	164	157	154
1A4. Other sectors	255	311	342	489	505	487	467	405	944	700	672	717	735
1B. Fugitive emissions from fuels	4,973	2,647	1,836	976	982	975	947	916	885	867	851	816	807
1B1. Solid fuels	4,760	2,394	1,563	655	644	609	590	577	564	552	545	533	539
1B2. Oil and natural gas and other emissions	213	253	273	322	339	366	357	339	321	315	305	283	267
2. Industrial processes and product use	61	58	54	54	55	51	50	51	54	54	46	46	43
3. Agriculture	29,838	30,186	28,371	28,370	27,920	28,546	28,704	28,110	29,009	28,635	28,064	27,954	27,559
3A. Enteric fermentation	9,064	8,993	8,682	8,287	8,305	8,320	8,204	8,094	7,829	7,793	7,606	7,399	7,223
3B. Manure management	3,353	3,146	2,879	2,733	2,676	2,634	2,596	2,569	2,518	2,521	2,472	2,410	2,361
3C. Rice cultivation	17,294	17,936	16,714	17,265	16,856	17,511	17,825	17,371	18,589	18,248	17,916	18,073	17,904
3F. Field burning of agricultural residue	127	111	96	86	83	81	78	76	74	73	71	72	72
4. LULUCF	73	70	67	67	59	58	81	65	60	61	56	58	76
5. Waste	12,291	11,455	9,877	8,065	7,715	7,350	7,006	6,641	6,254	6,007	5,763	5,541	5,366
5A. Solid waste disposal	9,221	8,619	7,236	5,703	5,383	5,080	4,717	4,413	4,107	3,861	3,655	3,459	3,314
5B. Biological treatment of solid waste	195	191	194	340	350	337	380	377	329	362	359	355	355
5C. Incineration and open burning of waste	16	18	16	17	16	14	14	12	12	11	12	12	11
5D. Wastewater treatment and discharge	2,860	2,628	2,432	2,006	1,967	1,919	1,895	1,839	1,806	1,772	1,738	1,714	1,687
Total (including LULUCF)	48,655	45,877	41,541	39,005	38,253	38,509	38,320	37,235	38,332	37,342	36,509	36,123	35,558
Total (excluding LULUCF)	48,582	45,807	41,474	38,938	38,195	38,451	38,239	37,170	38,272	37,282	36,453	36,066	35,482

* LULUCF: Land Use, Land-Use Change and Forestry

2.1.4. N_2O

Nitrous oxide emissions in FY2014 were 21.0 million tonnes (in CO_2 eq., including LULUCF), accounting for 1.5% of total GHGs emissions. They decreased by 32.3% since FY1990 and by 2.9% compared to the previous year. Their decrease since FY1990 is mainly a result of a 85.4% decrease in emissions from industrial processes and product use (e.g. adipic acid production in the chemical industry). There is a sharp decline in emissions from the industrial processes and product use from FY1998 to 1999, as N_2O abatement equipment came on stream in the adipic acid production plant in March 1999. However the N_2O emissions increased in FY2000 because of a decrease in the equipment's efficiency; the emissions decreased again in FY2001 with the resumption of normal operation.

Breakdown of the FY2014 emissions shows that the largest source is agricultural soils accounting for 27%. It is followed by fuel combustion (stationary sources) (22%) and manure management (21%).

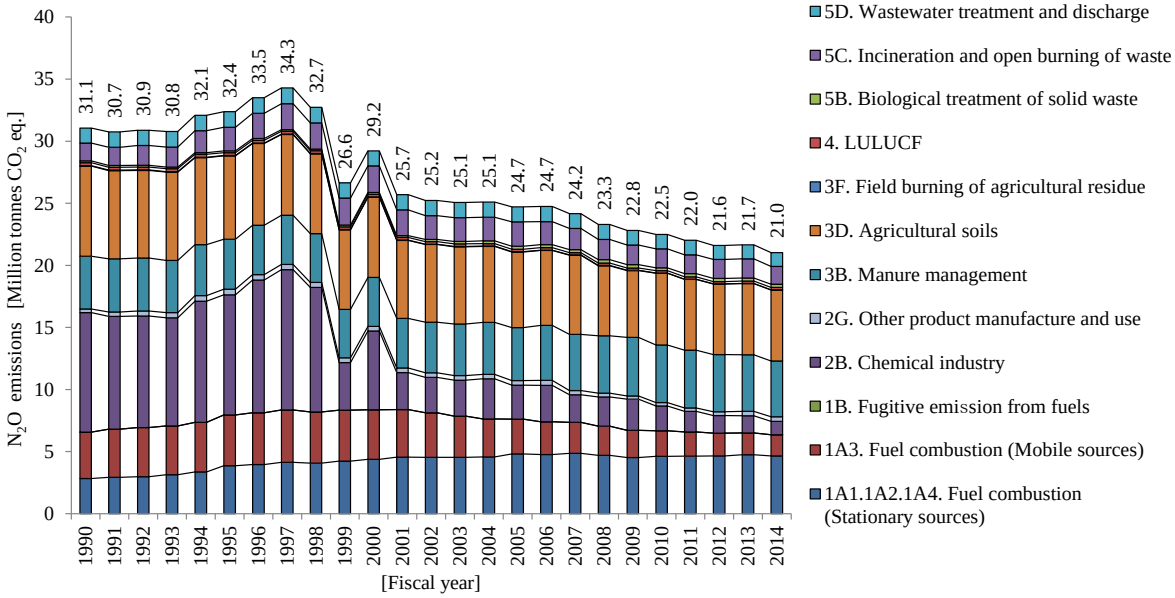


Figure 2-7 Trends in N_2O emissions

Table 2-4 Trends in N_2O emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1A. Fuel combustion	6,570	7,955	8,368	7,617	7,395	7,353	7,053	6,701	6,671	6,575	6,481	6,497	6,350
1A1. Energy industries	1,197	1,737	2,056	2,442	2,425	2,489	2,442	2,356	2,374	2,559	2,574	2,620	2,550
1A2. Manufacturing industries and construction	1,384	1,810	1,984	2,005	1,990	2,034	1,959	1,835	1,856	1,801	1,824	1,862	1,804
1A3. Transport	3,739	4,104	3,997	2,817	2,638	2,501	2,351	2,189	2,055	1,939	1,829	1,747	1,707
1A4. Other sectors	249	304	331	354	343	328	302	321	386	277	254	267	289
1B. Fugitive emissions from fuels	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2. Industrial processes and product use	9,911	10,114	6,720	3,093	3,339	2,564	2,647	2,777	2,270	1,931	1,727	1,748	1,449
2B. Chemical industry	9,620	9,665	6,348	2,726	2,944	2,228	2,350	2,518	1,995	1,661	1,420	1,389	1,078
2G. Other product manufacture and use	291	449	371	368	395	336	297	259	275	270	308	359	371
3. Agriculture	11,550	10,784	10,423	10,385	10,490	10,921	10,290	10,124	10,445	10,381	10,305	10,307	10,235
3B. Manure management	4,249	4,038	3,936	4,278	4,422	4,524	4,625	4,710	4,650	4,654	4,597	4,543	4,494
3D. Agricultural soils	7,262	6,712	6,457	6,081	6,042	6,373	5,641	5,391	5,772	5,705	5,686	5,741	5,720
3F. Field burning of agricultural residue	39	34	30	26	26	25	24	23	23	22	22	22	22
4. LULUCF	239	229	215	200	196	193	191	186	184	182	180	181	183
5. Waste	2,781	3,297	3,489	3,421	3,318	3,139	3,104	3,028	2,926	2,948	2,912	2,927	2,814
5B. Biological treatment of solid waste	139	137	139	243	250	241	271	269	236	259	257	254	254
5C. Incineration and open burning of waste	1,435	1,905	2,155	1,963	1,843	1,694	1,629	1,571	1,517	1,524	1,528	1,542	1,436
5D. Wastewater treatment and discharge	1,207	1,256	1,195	1,214	1,224	1,204	1,204	1,188	1,174	1,165	1,127	1,131	1,124
Total (including LULUCF)	31,051	32,380	29,214	24,717	24,737	24,170	23,286	22,816	22,496	22,018	21,606	21,658	21,031
Total (excluding LULUCF)	30,812	32,150	28,999	24,517	24,541	23,977	23,095	22,630	22,312	21,836	21,426	21,478	20,848

* LULUCF: Land Use, Land-Use Change and Forestry

2.1.5. HFCs

Hydrofluorocarbons emissions in CY2014[6] were 35.8 million tonnes (in CO_2 eq.), accounting for 2.6% of total GHGs emissions. They increased by 124.6% since CY1990, and by 11.5% compared to the previous year. Their increase since CY1990 is mainly a result of an increase in emissions from refrigeration and air conditioning (+32.6 million tonnes CO_2 eq.) substituting HCFC (an ozone depleting substance), despite a decrease in emissions of HFC-23 (-99.9%) produced as a by-product of HCFC-22 production due to regulation under the Act on the Protection of the Ozone Layer Through the Control of Specified Substances and Other Measures.

Breakdown of the CY2014 emissions shows that the largest source is refrigerants of refrigeration and air conditioning equipment accounting for 91%. It is followed by foam blowing agents (7%).

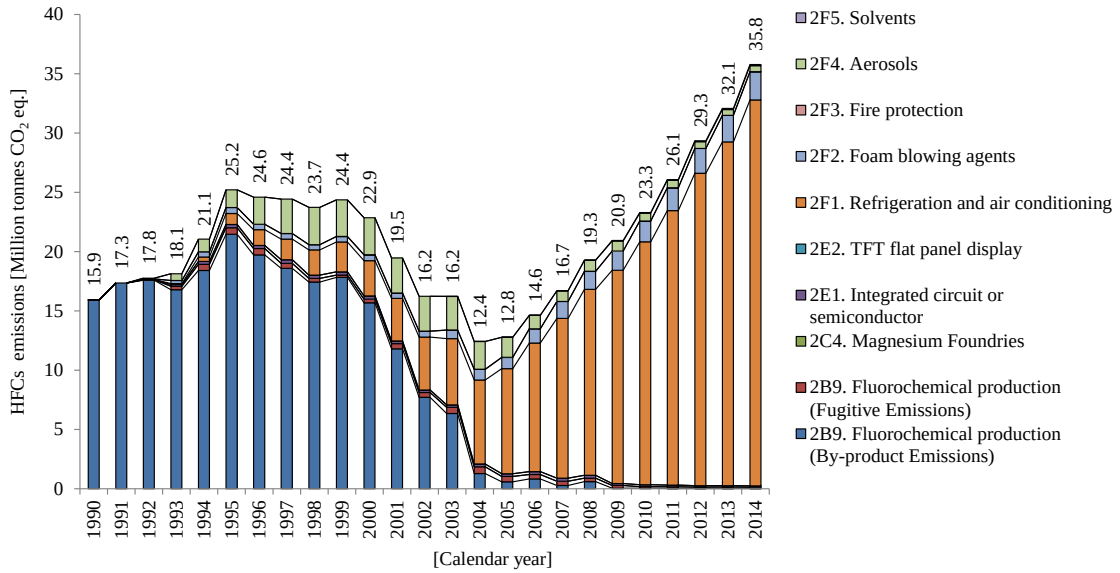


Figure 2-8 Trends in HFCs emissions

Table 2-5 Trends in HFCs emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B9. Fluorochemical production	15,930	22,019	15,984	1,035	1,198	632	900	284	181	168	138	147	124
By-product Emissions	15,929	21,460	15,688	586	831	275	593	50	53	16	18	16	24
Fugitive Emissions	2	559	296	449	367	357	306	234	128	151	120	131	101
2C4. Magnesium production	NO	NO	NO	NO	NO	NO	NO	NO	NO	1	1	1	1
2E. Electronics industry	1	271	285	227	246	266	237	152	168	145	124	112	115
2E1. Integrated circuit or semiconductor	1	271	283	224	243	263	234	150	165	142	122	109	113
2E2. TFT flat panel display	0.001	0.3	2	3	3	3	3	2	3	3	2	2	2
2F. Product uses as substitutes for ODS	1	2,923	6,583	11,519	13,184	15,809	18,148	20,501	22,956	25,757	29,085	31,827	35,544
2F1. Refrigeration and air conditioning	NO	925	2,977	8,876	10,854	13,468	15,685	17,998	20,482	23,139	26,353	29,002	32,556
2F2. Foam blowing agents	1	497	484	937	1,194	1,429	1,510	1,608	1,749	1,923	2,081	2,229	2,373
2F3. Fire protection	NO	NO	5	7	7	8	8	8	8	8	9	9	9
2F4. Aerosols	NO	1,502	3,117	1,695	1,123	895	931	845	666	634	561	489	503
2F5. Solvents	NO	NO	NO	4	5	10	14	42	50	52	81	98	103
Total	15,932	25,213	22,852	12,782	14,627	16,707	19,285	20,937	23,305	26,071	29,348	32,088	35,785

[6] Emissions of HFCs, PFCs, SF_6, and NF_3 are estimated on a calendar year (CY) basis.

2.1.6. PFCs

Perfluorocarbons emissions in CY2014 were 3.4 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 48.6% since CY1990, and increased by 2.5% compared to the previous year. Their decrease since CY1990 is mainly a result of a decrease in emissions from the solvents. (-66.2%)

Breakdown of the CY2014 emissions shows that the largest source is semiconductor for manufacture accounting for 48%. It is followed by solvents such as those for washing metals (46%) and fugitive emissions from fluorochemical production (PFCs) (3%).

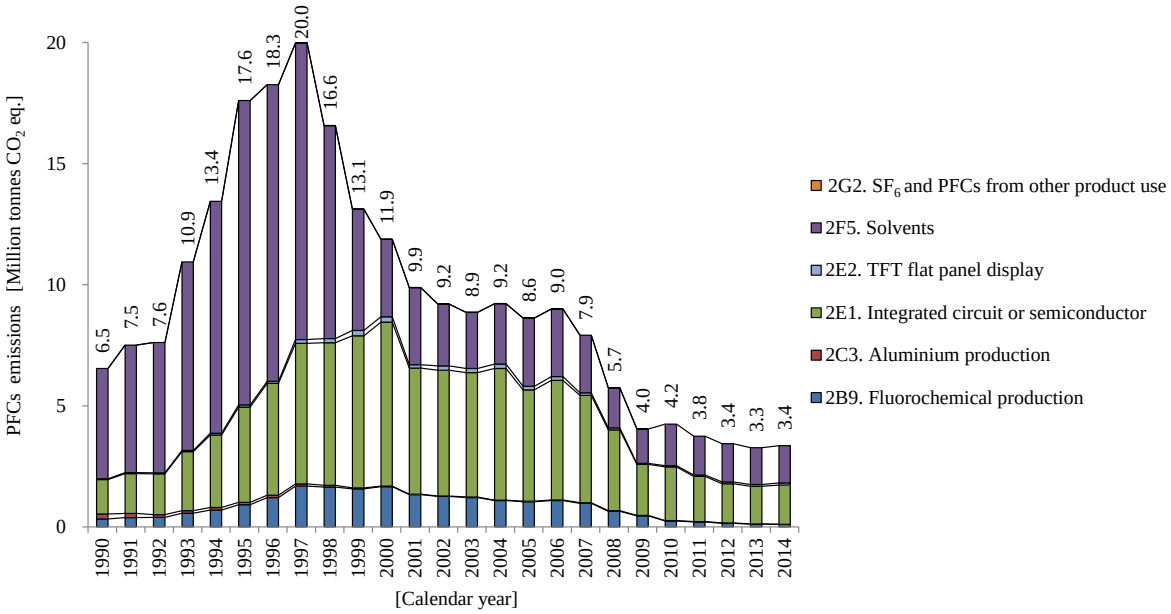


Figure 2-9 Trends in PFCs emissions

Table 2-6 Trends in PFCs emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B9. Fluorochemical production	331	914	1,661	1,041	1,091	977	649	459	248	206	148	111	107
2C3. Aluminium production	204	104	26	22	22	22	22	16	15	15	13	10	2
2E. Electronics industry	1,455	4,020	6,986	4,746	5,092	4,540	3,422	2,148	2,261	1,922	1,692	1,631	1,707
2E1. Integrated circuit or semiconductor	1,423	3,933	6,771	4,594	4,935	4,433	3,339	2,109	2,214	1,863	1,624	1,556	1,617
2E2. TFT flat panel display	31	87	214	152	158	107	83	39	46	59	68	76	90
2F5. Solvents	4,550	12,572	3,200	2,815	2,793	2,377	1,648	1,420	1,721	1,605	1,583	1,518	1,537
2G2. SF_6 and PFCs from other product use	NO	NO	NO	0.3	0.6	1.4	2	3	4	6	NO	10	9
Total	6,539	17,610	11,873	8,623	8,999	7,917	5,743	4,047	4,250	3,755	3,436	3,280	3,361

2.1.7. SF_6

Sulfur hexafluoride emissions in CY2014 were 2.1 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 83.9% since CY1990, and by 1.8% compared to the previous year. Their decrease since CY1990 is mainly a result of a decrease from electrical equipment, due to an enhancement of gas management system such as gas recovery largely in electric power companies. (-92.6%)

Breakdown of the CY2014 emissions shows that the largest source is other product use (e.g. accelerator, etc.) accounting for 41%. It is followed by electrical equipment (29%) and TFT flat panel display manufacture (9%).

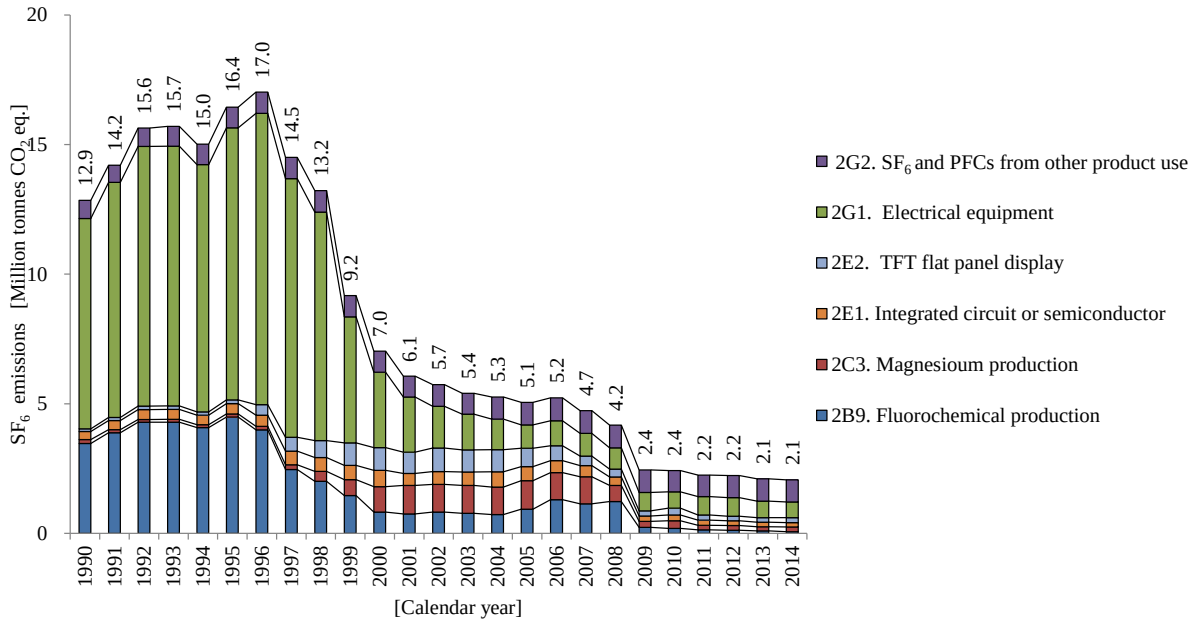


Figure 2-10 Trends in SF_6 emissions

Table 2-7 Trends in SF_6 emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B9. Fluorochemical production	3,471	4,492	821	930	1,303	1,144	1,229	233	189	132	123	93	62
2C3. Magnesioum production	147	114	980	1,104	1,041	1,039	622	228	294	182	182	160	182
2E. Electronics industry	419	542	1,506	1,252	1,036	796	625	410	494	394	356	351	366
2E1. Integrated circuit or semiconductor	309	400	629	540	463	431	329	211	225	196	184	181	175
2E2. TFT flat panel display	110	142	877	712	572	366	296	199	269	198	172	170	191
2G. Other product manufacture and use	8,814	11,300	3,724	1,767	1,849	1,754	1,701	1,576	1,447	1,539	1,573	1,498	1,455
2G1. Electrical equipment	8,112	10,498	2,910	899	967	880	828	711	622	707	719	643	602
2G2. SF_6 and PFCs from other product use	702	802	815	867	882	875	873	865	825	832	855	855	853
Total	12,850	16,448	7,031	5,053	5,229	4,733	4,177	2,447	2,424	2,248	2,235	2,102	2,064

2.1.8. NF_3

Nitrogen trifluoride emissions in CY2014 were 0.8 million tonnes (in CO_2 eq.), accounting for 0.1% of total GHGs emissions. They increased by a factor of 25 since CY1990, and decreased by 39.0% compared to the previous year. The increase since CY1990 is mainly a result of an increase in fugitives from florocarbon production (NF_3). (by a factor of 219)

Breakdown of the CY2014 emissions shows that the largest source is fluorochemical production accounting for 81%. It is followed by semiconductor manufacture (16%) and liquid crystal manufacture (3%).

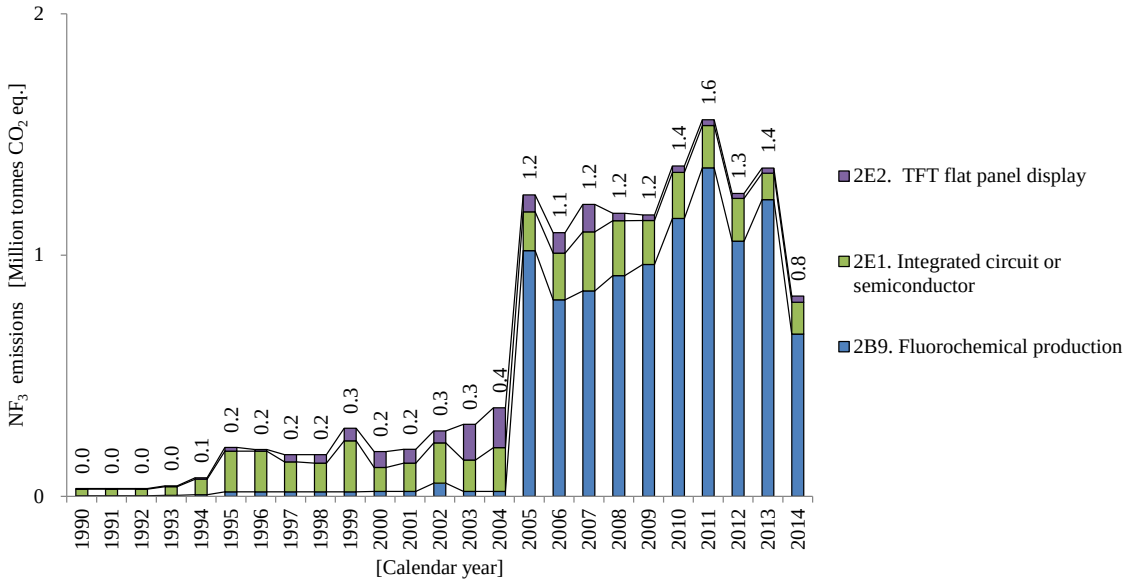


Figure 2-11 Trends in NF_3 emissions

Table 2-8 Trends in NF_3 emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2B9. Fluorochemical production	3	19	21	1,018	815	851	915	961	1,152	1,362	1,058	1,230	673
2E. Electronics industry	30	184	165	232	278	359	258	205	217	199	198	131	158
2E1. Integrated circuit or semiconductor	27	168	100	161	193	245	227	182	191	175	177	110	132
2E2. TFT flat panel display	3	16	66	71	85	114	31	23	26	24	21	21	26
Total	33	203	186	1,250	1,093	1,210	1,173	1,167	1,369	1,561	1,256	1,361	831

2.2. Description and Interpretation of Emission and Removal Trends by Categories

The breakdown of GHGs emissions and removals in FY2014 by sector[7] shows that energy accounts for 89.1% of total GHGs emissions. It is followed by industrial processes and product use (6.6%), agriculture (2.8%) and waste (1.6%).

Removals by LULUCF in FY2014 were equivalent to 4.5% of total GHGs emissions.

[7] As indicated in the *2006 IPCC Guidelines* and the CRF.

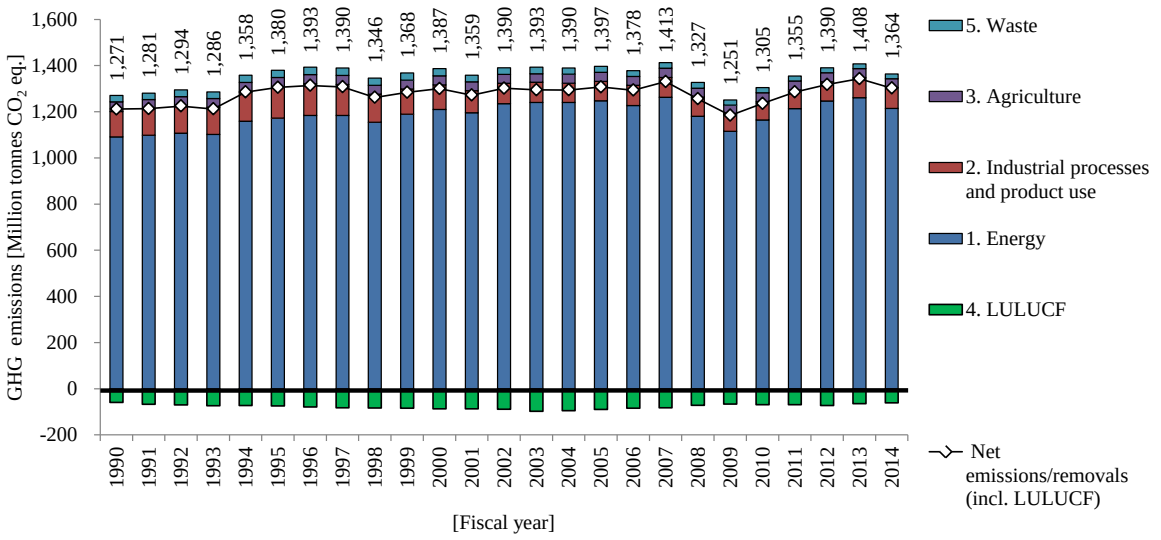


Figure 2-12 Trends in GHG emissions and removals in each sector

Table 2-9 Trends in GHG emissions and removals in each sector

[Million tonnes CO_2 eq.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy	1,091.2	1,098.4	1,107.2	1,101.4	1,158.7	1,172.0	1,183.8	1,183.7	1,154.4	1,189.4
2. Industrial processes and product use	109.3	113.7	115.5	117.7	125.0	135.1	137.1	134.1	121.5	108.7
3. Agriculture	42.0	40.7	42.4	37.9	43.2	41.3	40.5	40.0	38.2	38.6
4. LULUCF	-59.3	-67.5	-70.1	-73.9	-73.1	-74.7	-79.3	-82.6	-83.7	-84.2
5. Waste	28.2	28.1	29.3	28.8	31.3	31.5	31.7	32.1	31.7	31.2
Net emissions/removals (incl. LULUCF)	1,211.4	1,213.5	1,224.3	1,212.0	1,285.2	1,305.2	1,313.8	1,307.3	1,262.2	1,283.7
Emissions (excl. LULUCF)	1,270.7	1,280.9	1,294.4	1,285.9	1,358.3	1,379.9	1,393.1	1,389.9	1,345.8	1,367.9

[Million tonnes CO_2 eq.]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	1,209.8	1,195.4	1,234.9	1,240.5	1,240.0	1,247.0	1,226.8	1,262.2	1,180.1	1,115.2
2. Industrial processes and product use	106.6	95.5	88.5	87.1	83.8	84.8	87.4	86.5	82.2	74.9
3. Agriculture	39.2	38.6	38.8	37.3	38.9	39.2	38.8	40.0	39.4	38.6
4. LULUCF	-86.8	-86.9	-88.5	-98.0	-95.4	-89.9	-84.4	-82.5	-71.5	-66.6
5. Waste	31.0	29.2	28.1	27.8	26.9	26.1	24.8	24.1	25.4	22.2
Net emissions/removals (incl. LULUCF)	1,299.9	1,271.8	1,301.8	1,294.7	1,294.2	1,307.2	1,293.4	1,330.3	1,255.7	1,184.4
Emissions (excl. LULUCF)	1,386.7	1,358.7	1,390.3	1,392.7	1,389.6	1,397.1	1,377.9	1,412.8	1,327.2	1,251.0

[Million tonnes CO_2 eq.]	2010	2011	2012	2013	2014
1. Energy	1,164.4	1,213.6	1,246.9	1,260.6	1,214.7
2. Industrial processes and product use	78.4	80.2	82.8	87.0	89.6
3. Agriculture	39.9	39.4	38.9	38.8	38.4
4. LULUCF	-69.1	-69.3	-72.6	-65.0	-61.5
5. Waste	22.3	21.4	21.7	21.4	21.1
Net emissions/removals (incl. LULUCF)	1,235.8	1,285.3	1,317.7	1,342.8	1,302.4
Emissions (excl. LULUCF)	1,304.9	1,354.6	1,390.3	1,407.9	1,363.9

* LULUCF: Land Use, Land-Use Change and Forestry

2.2.1. Energy

Emissions from the energy sector in FY2014 were 1,215 million tonnes (in CO_2 equivalents). They increased by 11.3% since FY1990 and decreased by 3.6% compared to the previous year.

Breakdown of the FY2014 emissions shows that CO_2 from fuel combustion accounts for 99.2%. The largest source within fuel combustion[8] is solid fuel CO_2, which accounted for 38.1%, and is then followed by liquid fuel CO_2 (38.0%) and gaseous fuel CO_2 (22%).

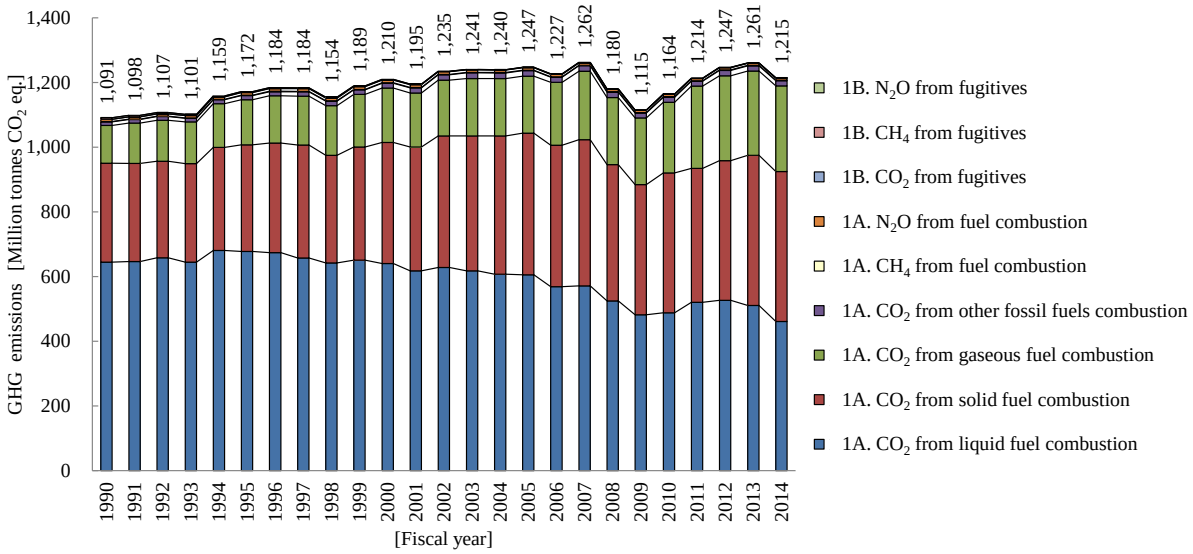


Figure 2-13 Trends in GHG emissions from the energy sector

Table 2-10 Trends in GHG emissions from the energy sector

[Thousand tonnes CO_2 eq.]

Source category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1A. Fuel combustion	1,086,071	1,168,867	1,207,488	1,245,553	1,225,311	1,260,615	1,178,604	1,113,800	1,163,080	1,212,253	1,245,608	1,259,384	1,213,465
Liquid fuel CO_2	644,730	677,734	640,355	605,901	569,135	571,149	525,131	481,800	488,214	520,447	526,948	510,800	461,428
Solid fuel CO_2	305,968	329,370	374,429	437,445	437,076	451,963	420,978	402,354	432,060	414,290	431,427	464,277	463,276
Gaseous fuel CO_2	116,536	139,951	167,825	176,128	194,146	211,905	207,523	206,203	218,823	253,920	262,639	260,226	264,853
Other fossil fuels (Waste) CO_2	10,849	12,398	15,175	16,989	16,037	16,717	16,386	15,292	15,241	15,301	16,385	15,877	15,851
CH_4	1,419	1,460	1,336	1,473	1,523	1,529	1,533	1,451	2,071	1,719	1,729	1,708	1,707
N_2O	6,570	7,955	8,368	7,617	7,395	7,353	7,053	6,701	6,671	6,575	6,481	6,497	6,350
1B. Fugitive emissions from fuel	5,165	3,169	2,347	1,484	1,536	1,591	1,512	1,417	1,360	1,345	1,341	1,255	1,233
CO_2	192	521	512	508	553	616	565	501	475	477	490	438	426
CH_4	4,973	2,647	1,836	976	982	975	947	916	885	867	851	816	807
N_2O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1C. CO_2 transport and storage	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
Total	1,091,236	1,172,036	1,209,836	1,247,037	1,226,847	1,262,206	1,180,116	1,115,218	1,164,439	1,213,598	1,246,949	1,260,639	1,214,698

2.2.2. Industrial Processes and Product Use

Emissions from the industrial processes sector in FY2014 were 89.6 million tonnes (in CO_2 eq.). They decreased by 18.0% since FY1990, and increased by 3.0% compared to the previous year.

The breakdown of GHGs emissions from this sector in FY2014 shows that the largest source is HFCs emissions from product uses as ODS substitutes accounting for 40%. It is followed by the mineral industry emissions such as CO_2 emissions from cement production (39%) and CO_2 emissions from

[8] Fuel types are categorized in accordance with classification indicated in the *2006 IPCC Guidelines* and the CRF.

the metal industry (7%).

The main driving factors for decrease in emissions since FY1990 are the decrease in emissions of HFC-23 produced as a by-product of HCFC-22 production due to regulation under the Act on the Protection of the Ozone Layer Through the Control of Specified Substances and Other Measures (chemical industry), the decrease in CO_2 emissions from cement production (mineral industry) as the clinker production declined, the decrease in N_2O emissions from adipic acid production (chemical industry) as the N_2O abatement equipment came on stream.

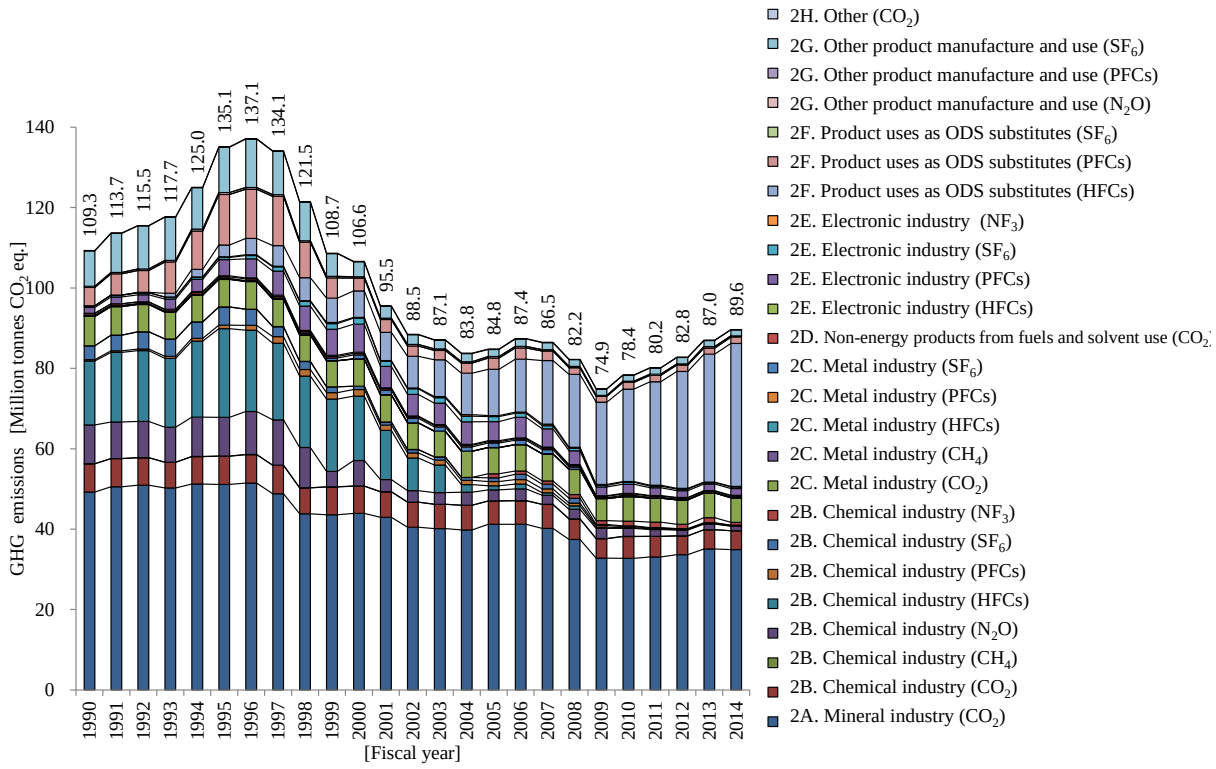


Figure 2-14 Trends in GHG emissions from the industrial processes sector

Table 2-11 Trends in GHG emissions from the industrial processes sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2A. Mineral industry (CO_2)	49,219	51,131	43,899	41,220	41,192	40,200	37,432	32,776	32,748	33,091	33,661	35,054	34,924
2B. Chemical industry	36,428	44,156	31,676	12,572	13,253	11,822	11,176	9,357	9,223	8,662	7,560	7,780	6,751
CO_2	7,036	7,010	6,807	5,788	5,867	5,959	5,101	4,866	5,420	5,097	4,645	4,782	4,683
CH_4	37	37	34	34	34	30	32	36	36	36	28	28	25
N_2O	9,620	9,665	6,348	2,726	2,944	2,228	2,350	2,518	1,995	1,661	1,420	1,389	1,078
HFCs	15,930	22,019	15,984	1,035	1,198	632	900	284	181	168	138	147	124
PFCs	331	914	1,661	1,041	1,091	977	649	459	248	206	148	111	107
SF_6	3,471	4,492	821	930	1,303	1,144	1,229	233	189	132	123	93	62
NF_3	3	19	21	1,018	815	851	915	961	1,152	1,362	1,058	1,230	673
2C. Metal industry	7,646	7,088	7,766	7,642	7,651	7,776	6,898	5,728	6,427	6,181	6,276	6,358	6,338
CO_2	7,273	6,850	6,740	6,496	6,568	6,695	6,237	5,468	6,101	5,965	6,061	6,170	6,135
CH_4	23	21	20	20	20	21	18	15	18	18	18	18	18
HFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	1	1	1	1
PFCs	204	104	26	22	22	22	22	16	15	15	13	10	2
SF_6	147	114	980	1,104	1,041	1,039	622	228	294	182	182	160	182
2D. Non-energy products from fuels and solvent use (CO_2)	392	390	385	361	368	356	329	333	339	316	288	299	295
2E. Electronic industry	1,904	5,016	8,941	6,457	6,652	5,960	4,542	2,916	3,140	2,661	2,370	2,225	2,346
HFCs	1	271	285	227	246	266	237	152	168	145	124	112	115
PFCs	1,455	4,020	6,986	4,746	5,092	4,540	3,422	2,148	2,261	1,922	1,692	1,631	1,707
SF_6	419	542	1,506	1,252	1,036	796	625	410	494	394	356	351	366
NF_3	30	184	165	232	278	359	258	205	217	199	198	131	158
2F. Product uses as ODS substitutes	4,551	15,495	9,783	14,334	15,976	18,186	19,796	21,921	24,676	27,362	30,668	33,345	37,081
HFCs	1	2,923	6,583	11,519	13,184	15,809	18,148	20,501	22,956	25,757	29,085	31,827	35,544
PFCs	4,550	12,572	3,200	2,815	2,793	2,377	1,648	1,420	1,721	1,605	1,583	1,518	1,537
SF_6	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2G. Other product manufacture and use	9,105	11,749	4,096	2,135	2,245	2,091	2,001	1,838	1,727	1,815	1,881	1,867	1,835
N_2O	291	449	371	368	395	336	297	259	275	270	308	359	371
PFCs	NO	NO	NO	0.3	1	1	2	3	4	6	NO	10	9
SF_6	8,814	11,300	3,724	1,767	1,849	1,754	1,701	1,576	1,447	1,539	1,573	1,498	1,455
2H. Other (CO_2)	64	72	87	90	88	86	72	71	76	76	76	82	80
Total	109,310	135,098	106,634	84,810	87,425	86,479	82,246	74,940	78,355	80,165	82,780	87,012	89,650

2.2.3. Agriculture

Emissions from the agriculture sector in FY2014 were 38.4 million tonnes (in CO_2 eq.). They decreased by 8.6% since FY1990 and by 1.2% compared to the previous year.

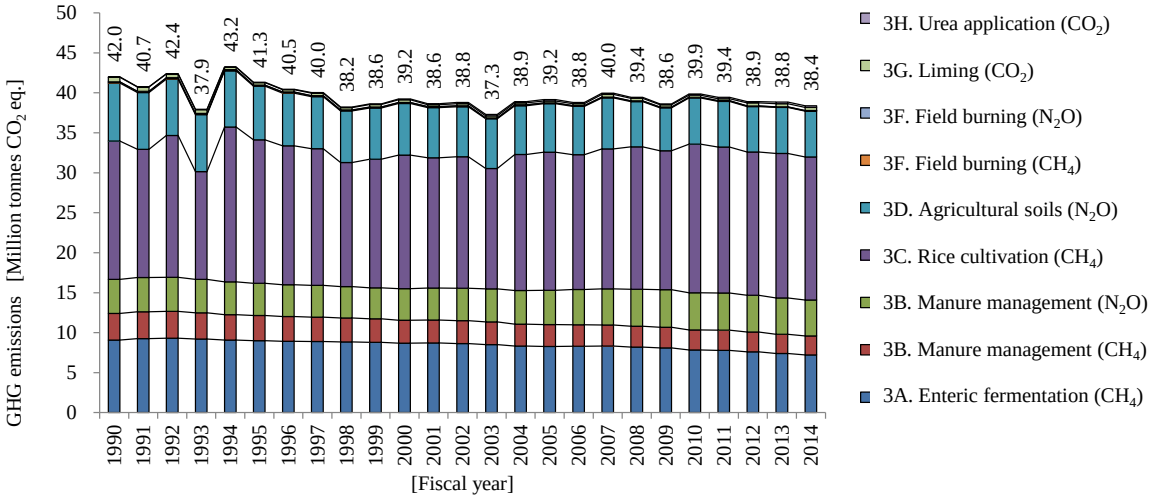


Figure 2-15 Trends in GHG emissions from the agriculture sector

Breakdown of the FY2014 emissions from this sector shows that the largest source is the rice cultivation (CH_4) accounting for 47%. It is followed the enteric fermentation (CH_4) by (19%), and the agricultural soils (N_2O) (15%) as a result of the nitrogen-based fertilizer applications.

The main driving factor for the decrease in emissions since FY1990 is the decrease in CH_4 emissions from enteric fermentation due to the decrease in the number of dairy cattle, and the decrease in N_2O emissions from the agricultural soils, because the amount of nitrogen fertilizers applied to cropland had decreased.

Table 2-12 Trends in GHG emissions from the agriculture sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
3A. Enteric fermentation (CH_4)	9,064	8,993	8,682	8,287	8,305	8,320	8,204	8,094	7,829	7,793	7,606	7,399	7,223
3B. Manure management	7,602	7,183	6,815	7,011	7,098	7,158	7,222	7,279	7,168	7,175	7,069	6,954	6,854
CH_4	3,353	3,146	2,879	2,733	2,676	2,634	2,596	2,569	2,518	2,521	2,472	2,410	2,361
N_2O	4,249	4,038	3,936	4,278	4,422	4,524	4,625	4,710	4,650	4,654	4,597	4,543	4,494
3C. Rice cultivation (CH_4)	17,294	17,936	16,714	17,265	16,856	17,511	17,825	17,371	18,589	18,248	17,916	18,073	17,904
3D. Agricultural soils (N_2O)	7,262	6,712	6,457	6,081	6,042	6,373	5,641	5,391	5,772	5,705	5,686	5,741	5,720
3F. Field burning of agricultural residues	166	145	126	112	109	106	102	99	96	95	93	94	94
CH_4	127	111	96	86	83	81	78	76	74	73	71	72	72
N_2O	39	34	30	26	26	25	24	23	23	22	22	22	22
3G. Liming (CO_2)	550	304	333	231	230	325	306	270	243	247	370	380	380
3H. Urea application (CO_2)	59	56	110	179	153	175	134	120	160	168	150	198	198
Total	41,998	41,329	39,236	39,166	38,794	39,968	39,434	38,624	39,857	39,430	38,890	38,839	38,372

2.2.4. Land Use, Land Use Change and Forestry (LULUCF)

Net removals (including CO_2, CH_4 and N_2O emissions) from the LULUCF sector in FY2014 was 61.5 million tonnes (in CO_2 eq.). They increased by 3.7% since FY1990 and decreased by 5.5% compared to the previous year. The declining trend in removals in recent years is largely due to the maturity of Japanese forests. The emissions from cropland and settlements have decreased since FY1990, because the land-use conversions to those land-use categories decreased due to economic depression and the decline of agriculture, etc.

Breakdown of the FY2014 emissions and removals from this sector shows that the largest sink - forest land and its removals were 65.4 million tonnes, accounting for 106% of this sector's net total emissions / removals.

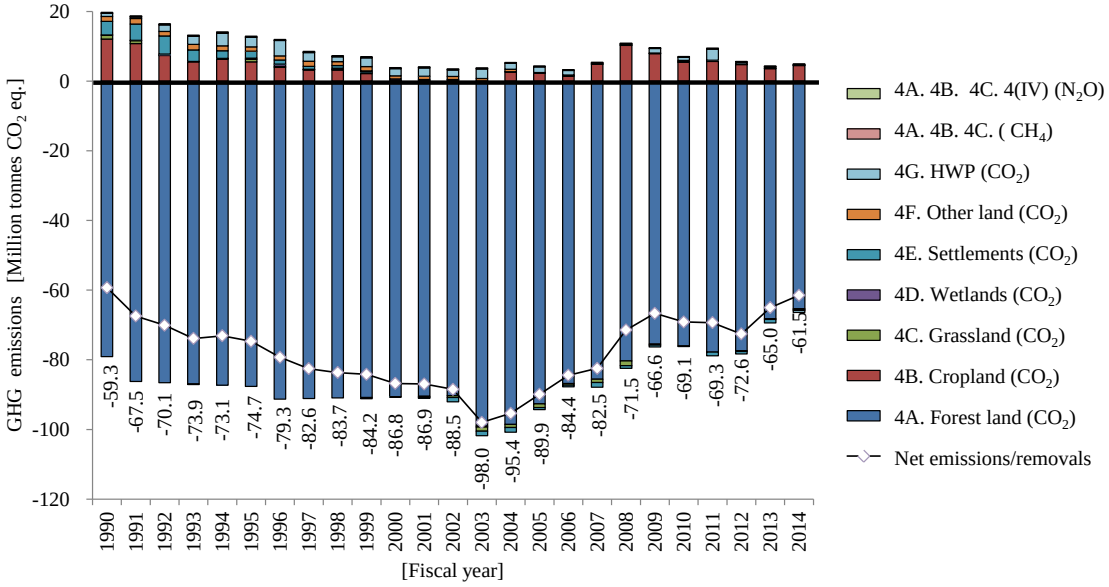


Figure 2-16 Trends in GHG emissions and removals from the LULUCF sector

Table 2-13 Trends in GHG emissions and removals from the LULUCF sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
4A. Forest land	-78,938	-87,476	-90,508	-92,528	-86,692	-85,428	-80,197	-75,376	-75,919	-77,687	-77,277	-68,044	-65,230
CO_2	-79,073	-87,612	-90,642	-92,664	-86,820	-85,556	-80,350	-75,511	-76,049	-77,819	-77,404	-68,174	-65,382
CH_4	10	10	9	11	3	2	26	10	5	6	2	4	23
N_2O	125	125	125	126	125	125	127	125	125	125	125	126.0	128.4
4B. Cropland	12,225	5,691	294	2,372	1,592	4,937	10,381	7,988	5,523	5,757	4,847	3,705	4,561
CO_2	12,107	5,584	200	2,291	1,514	4,861	10,309	7,917	5,455	5,690	4,780	3,639	4,496
CH_4	61	57	55	54	54	53	53	53	52	52	52	52	51
N_2O	58	50	38	27	25	22	20	18	16	15	14	14	14
4C. Grassland	1,117	701	50	-1,030	-475	-985	-1,335	-260	-154	170	-177	-234	-62
CO_2	1,111	694	43	-1,037	-482	-992	-1,342	-266	-160	163	-184	-241	-68
CH_4	2	2	2	2	2	2	2	2	2	2	2	2	2
N_2O	5	5	5	4	4	4	4	4	4	4	4	4	4
4D. Wetlands	85	336	399	53	54	31	42	69	66	45	38	41	41
CO_2	85	336	399	53	54	31	42	69	66	45	38	41	41
CH_4	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO
N_2O	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO	,NA,NE,NO
4E. Settlements	3,853	2,009	-74	-629	-471	-1,352	-736	-524	202	-1,059	-708	-1,023	-354
CO_2	3,853	2,009	-74	-629	-471	-1,352	-736	-524	202	-1,059	-708	-1,023	-354
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO	IE,NA,NO
4F. Other land	1,465	1,231	912	161	209	118	184	145	247	127	166	102	170
CO_2	1,455	1,220	902	153	201	110	177	139	241	121	161	97	166
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	11	11	10	9	8	8	7	7	6	6	5	5	4
4G. HWP (CO_2)	857	2,791	2,079	1,630	1,307	191	151	1,282	879	3,278	484	375	-621
4H. Other (CO_2)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4(IV) Indirect N_2O	41	39	36	34	34	33	33	32	32	32	32	32	32
Total	-59,295	-74,679	-86,812	-89,937	-84,441	-82,456	-71,477	-66,643	-69,124	-69,338	-72,595	-65,048	-61,463

2.2.5. Waste

Emissions from the waste sector in FY2014 were 21.1 million tonnes (in CO_2 eq.). They decreased by 25.0% since FY1990 and by 1.2% compared to the previous year.

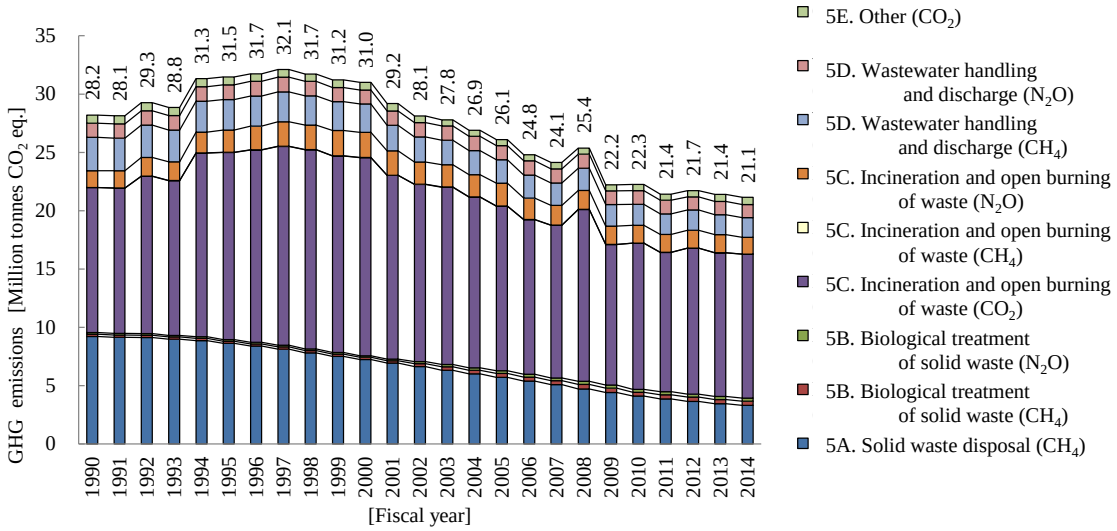


Figure 2-17 Trends in GHG emissions from the waste sector

Breakdown of the FY2014 emissions from this sector shows that the largest source is waste incineration (CO_2), associated with waste derived from fossil fuels such as waste plastic and waste oil, accounting for 58%. It is followed by solid waste disposal (CH_4) (16%) and wastewater treatment and discharge (CH_4) (8%).

The main driving factor for the decrease in emissions since FY1990 is the decrease in CH_4 emissions from solid waste disposal on land as a result of decrease in the amount of disposal of biodegradable waste due to improvement of volume reduction ratio by intermediate treatment under Waste Management and Public Cleansing Act, Basic Law for Establishing the Recycling-based Society, and other recycling laws.

Table 2-14 Trends in GHG emissions from the waste sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
5A. Solid waste disposal (CH_4)	9,221	8,619	7,236	5,703	5,383	5,080	4,717	4,413	4,107	3,861	3,655	3,459	3,314
5B. Biological treatment of solid waste	334	328	333	582	600	579	651	646	565	621	616	610	609
CH_4	195	191	194	340	350	337	380	377	329	362	359	355	355
N_2O	139	137	139	243	250	241	271	269	236	259	257	254	254
5C. Incineration and open burning of waste	13,876	17,963	19,157	16,076	15,101	14,800	16,376	13,622	14,072	13,479	14,058	13,876	13,792
CO_2	12,424	16,041	16,986	14,096	13,242	13,092	14,733	12,039	12,543	11,943	12,518	12,322	12,346
CH_4	16	18	16	17	16	14	14	12	12	11	12	12	11
N_2O	1,435	1,905	2,155	1,963	1,843	1,694	1,629	1,571	1,517	1,524	1,528	1,542	1,436
5D. Wastewater treatment and discharge	4,067	3,884	3,627	3,220	3,191	3,122	3,099	3,027	2,980	2,937	2,865	2,845	2,810
CH_4	2,860	2,628	2,432	2,006	1,967	1,919	1,895	1,839	1,806	1,772	1,738	1,714	1,687
N_2O	1,207	1,256	1,195	1,214	1,224	1,204	1,204	1,188	1,174	1,165	1,127	1,131	1,124
5E. Other (CO_2)	703	668	656	507	522	561	530	514	527	524	528	605	617
Total	28,200	31,462	31,008	26,089	24,797	24,142	25,373	22,222	22,251	21,423	21,722	21,394	21,142

2.3. Description and Interpretation of Emission Trends for Indirect GHGs and SO_X

Under the revised UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (24/CP.19), it is required to report emissions not only of the 7 types of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3), but also emissions of indirect GHGs (NO_X, CO and NMVOC) as well as SO_X. Their emission trends are indicated below.

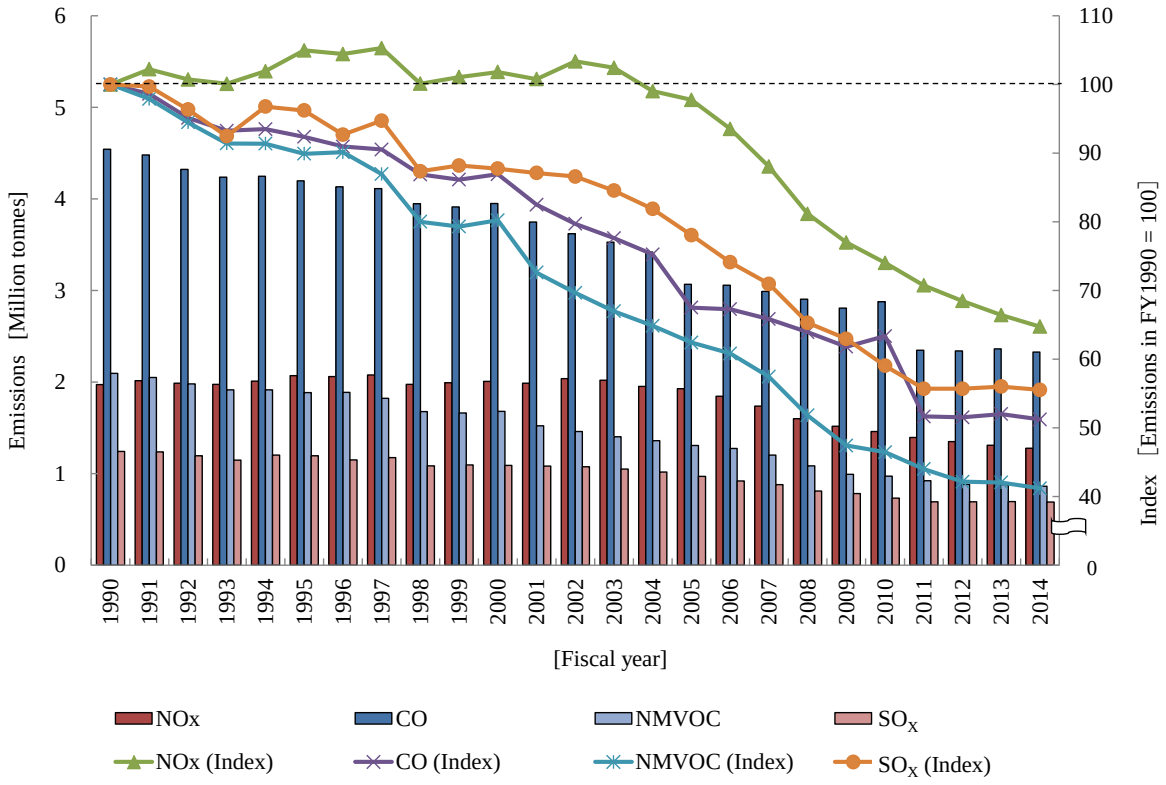
Nitrogen oxide (NO_X) emissions in FY2014 were 1,277 thousand tonnes. They decreased by 35.3% since FY1990 and by 2.5% compared to the previous year.

Carbon monoxide (CO) emissions in FY2014 were 2,327 thousand tonnes. They decreased by 48.8% since FY1990 and decreased by 1.5% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY2014 were 863 thousand tonnes. They decrease by 58.8% since FY1990 and decrease by 2.0% compared to the previous year.

Sulfur oxide (SO_X)[9] emissions in FY2014 were 689 thousand tonnes. They decreased by 44.5% since FY1990 and decreased by 0.9% compared to the previous year.

[9] Most SO_X consists of SO_2. For major sources, SO_2 emissions are estimated.



(* The line chart shows the trend as an index of FY1990 emissions set at 100.)

Figure 2-18 Trends in emissions of indirect GHGs and SO_X

2.4. Emissions and removals from KP-LULUCF activities

The net removals from Kyoto Protocol Article 3.3 and 3.4 activities in FY2014 were 45.4 million tonnes (in CO_2 eq.). The breakdown of emissions and removals to each activity in the second commitment period of the Kyoto Protocol is shown in Table 2-15. For detailed information, see Chapter 11.

Table 2-15 Accounting summary for activities under articles 3.3 and 3.4 of the Kyoto Protocol (CRF Accounting table)

GREENHOUSE GAS SOURCE AND SINK ACTIVITIES	Base Year (1990)	NET EMISSIONS/REMOVALS	
		2013	2014
	(kt CO_2 eq)		
A. Article 3.3 activities			
A.1. Afforestation/reforestation		-532	-531
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
A.2. Deforestation		1493	2134
B. Article 3.4 activities			
B.1. Forest management			
Net emissions/removals		-51070	-50033
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
Any debits from newly established forest (CEF-ne)		NA	NA
Forest management reference level (FMRL)		0	0
Technical corrections to FMRL		1268	1489
Forest management cap			
B.2. Cropland management (if elected)	10262	3554	4328
B.3. Grazing land management (if elected)	841	-300	-90
B.4. Revegetation (if elected)	-79	-1206	-1225
B.5. Wetland drainage and rewetting (not elected)	NA	NA	NA

* The total values and results of summing up each figure are not always the same because of the difference in display digit.

References

1. Cabinet Office, Government of Japan, *Annual Report on National Accounts.*
2. Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, 2007.
3. Ministry of Internal Affairs and Communications, Statistics Bureau, *Annual Report of Population Estimates.*
4. Ministry of Internal Affairs and Communications, Statistics Bureau, *Population Census.*

Chapter 3. Energy (CRF sector 1)

3.1. Overview of Sector

Emissions from the energy sector consist of two main categories: fuel combustion and fugitive emissions from fuels. Fuel combustion includes emissions released into the atmosphere when fossil fuels (e.g., coal, oil products, and natural gas) are combusted. Fugitive emissions are intentional or unintentional releases of gases from fossil fuels by anthropogenic activities.

In Japan, fossil fuels are used to produce energy for a wide variety of purposes (e.g., production, transportation, and consumption of energy products) and CO_2 (Carbon Dioxide), CH_4 (Methane), N_2O (Nitrous Oxide), NO_X (Nitrogen Oxide), CO (Carbon Monoxide), and NMVOC (Non-Methane Volatile Organic Compounds) are emitted in the process.

In FY2014, GHG emissions (CO_2, CH_4 and N_2O) from the energy sector accounted for 1,214,698 kt-CO_2 eq., and represented 89.1% of Japan's total GHG emissions (excluding LULUCF). The emissions from the energy sector had increased by 11.3% compared to FY1990.

The methodological tiers are shown in the below table.

Table 3-1 Mehodological tiers used in the energy sector

GREENHOUSE GAS SOURCE CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
1.A. Fuel combustion	CS,T2	CS	CS,T1,T2,T3	CR,CS,D	CS,T1,T2,T3	CR,CS,D
1. Energy industries	CS,T2	CS	CS,T3	CS	CS,T3	CS
2. Manufacturing industries and construction	CS,T2	CS	CS,T1,T3	CR,CS	CS,T1,T3	CR,CS
3. Transport	T2	CS	T1,T2,T3	CS,D	T1,T2,T3	CS,D
4. Other sectors	T2	CS	T1,T3	CR,CS,D	T1,T3	CR,CS,D
5. Other						
1.B. Fugitive emissions from fuels	CS,T1	CS,D	CS,D,T1,T2,T3	CS,D	T1	D
1. Solid fuels	CS	CS	D,T1,T2,T3	CS,D	NA	NA
2. Oil and natural gas	CS,T1	CS,D	CS,T1	CS,D	T1	D
1.C. CO_2 transport and storage	NA	NA				

(Note) D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country specific method or EF, CR: CORINAIR

3.2. Fuel Combustion (1.A.)

This category covers GHG emissions from combustion of fossil fuels such as coal, oil, and natural gas, and incineration of waste for energy purposes and with energy recovery.[1]

This section includes GHG emissions from five sources: energy industries (1.A.1):— emissions from power generation and heat supply; manufacturing industries and construction (1.A.2):— emissions from manufacturing industry and construction; transport (1.A.3):— emissions from transport of passenger and freight; other sectors (1.A.4):— emissions from commercial/institutional, residential, and agriculture/forestry/fishing sources; and other (1.A.5):— emissions from other sources.

[1] The emissions from waste incineration had been reported in the waste sector in the 2008 submission, regardless of their use as energy or energy recovery. However, to comply with ERT recommendations and the requirements of the IPCC Guidelines, the emissions are reported in the energy sector since the 2009 submission.

Table 3-2 Trends in GHGs emissions from fuel combustion (1.A)

Gas	Item		Unit	1990	1995	2000	2005	2009	2010	2011	2012	2013	2014
CO_2	1.A.1. Energy industries	a. Public electricity and heat production	kt-CO_2	300,173	318,716	334,091	382,780	360,396	383,263	444,486	490,975	495,608	470,348
		b. Petroleum refining	kt-CO_2	37,150	41,766	47,377	50,884	47,307	49,627	46,429	45,144	47,454	41,973
		c. Manufacture of solid fuels and other energy industries	kt-CO_2	15,460	16,546	11,592	14,279	29,067	28,290	27,698	25,767	21,128	19,414
	1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-CO_2	167,331	155,182	163,244	172,177	139,438	159,485	153,689	159,085	164,755	168,837
		b. Non-ferrous metals	kt-CO_2	8,409	7,080	5,536	5,389	4,389	3,073	3,177	3,159	3,398	2,999
		c. Chemicals	kt-CO_2	63,684	73,044	65,825	59,926	55,790	55,741	54,606	52,242	57,061	53,962
		d. Pulp, paper and print	kt-CO_2	28,247	33,041	32,272	30,010	23,538	24,011	25,056	23,262	25,030	22,633
		e. Food processing, beverages and tobacco	kt-CO_2	17,039	19,828	23,810	25,905	17,666	24,818	24,494	23,298	17,813	14,634
		f. Non-metallic minerals	kt-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
		g. Other	kt-CO_2	95,401	94,687	88,974	81,171	62,106	71,279	73,826	72,702	73,705	65,155
	1.A.3. Transport	a. Domestic aviation	kt-CO_2	7,162	10,278	10,677	10,799	9,781	9,193	9,001	9,524	10,149	10,172
		b. Road transportation	kt-CO_2	178,442	214,684	222,613	208,267	193,931	194,956	192,661	196,765	194,172	186,582
		c. Railways	kt-CO_2	935	822	711	647	590	574	555	554	540	540
		d. Domestic Navigation	kt-CO_2	13,675	14,669	15,012	13,014	10,462	10,745	10,434	10,594	10,942	10,993
	1.A.4. Other sectors	a. Commercial/institutional	kt-CO_2	80,186	86,868	102,040	109,061	89,123	73,851	74,603	61,620	69,342	79,441
		b. Residential	kt-CO_2	58,366	68,310	71,037	69,614	59,611	62,883	60,670	60,039	57,660	55,497
		c. Agriculture/forestry/fishing	kt-CO_2	6,421	3,931	2,972	2,540	2,453	2,551	2,574	2,669	2,423	2,226
	1.A.5 Other	a. Stationary	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-CO_2	1,078,082	1,159,452	1,197,784	1,236,463	1,105,649	1,154,339	1,203,959	1,237,398	1,251,180	1,205,408
CH_4	1.A.1. Energy industries	a. Public electricity and heat production	kt-CH_4	1.34	1.55	1.89	1.36	1.24	2.57	5.97	7.60	5.94	5.51
		b. Petroleum refining	kt-CH_4	0.10	0.12	0.22	1.53	2.45	2.53	0.13	0.12	0.14	0.12
		c. Manufacture of solid fuels and other energy industries	kt-CH_4	15.82	14.44	8.11	5.66	8.85	8.82	8.72	8.18	6.89	6.34
	1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-CH_4	6.44	5.54	5.96	8.77	7.98	9.77	6.40	6.97	6.92	7.72
		b. Non-ferrous metals	kt-CH_4	0.59	0.51	0.44	0.38	0.34	0.16	0.18	0.23	0.23	0.19
		c. Chemicals	kt-CH_4	0.34	0.36	0.52	1.40	2.30	2.70	1.09	1.10	1.08	1.01
		d. Pulp, paper and print	kt-CH_4	1.18	1.15	1.17	1.52	1.94	2.11	1.87	1.78	1.94	1.99
		e. Food processing, beverages and tobacco	kt-CH_4	0.15	0.24	0.26	0.24	0.18	0.25	0.46	0.43	0.35	0.25
		f. Non-metallic minerals	kt-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
		g. Other	kt-CH_4	8.94	9.69	8.73	8.56	9.09	9.02	9.18	9.29	9.89	9.61
	1.A.3. Transport	a. Domestic aviation	kt-CH_4	0.23	0.26	0.29	0.22	0.07	0.07	0.06	0.06	0.07	0.07
		b. Road transportation	kt-CH_4	10.10	10.68	10.77	8.44	6.38	6.01	5.70	5.47	5.20	5.09
		c. Railways	kt-CH_4	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
		d. Domestic Navigation	kt-CH_4	1.27	1.36	1.39	1.20	0.97	1.00	0.97	0.99	0.97	0.98
	1.A.4. Other sectors	a. Commercial/institutional	kt-CH_4	1.34	3.41	5.17	11.54	9.49	30.64	21.09	20.14	22.21	23.19
		b. Residential	kt-CH_4	8.29	8.70	8.25	7.84	6.57	6.97	6.72	6.56	6.29	6.03
		c. Agriculture/forestry/fishing	kt-CH_4	0.57	0.34	0.25	0.20	0.16	0.17	0.18	0.19	0.17	0.16
	1.A.5 Other	a. Stationary	kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-CH_4	56.76	58.40	53.45	58.91	58.03	82.82	68.76	69.14	68.32	68.29
			kt-CO_2 eq.	1,419	1,460	1,336	1,473	1,451	2,071	1,719	1,729	1,708	1,707
N_2O	1.A.1. Energy industries	a. Public electricity and heat production	kt-N_2O	2.88	4.40	5.27	6.48	6.02	6.05	6.92	7.00	7.34	7.23
		b. Petroleum refining	kt-N_2O	1.07	1.33	1.58	1.61	1.60	1.63	1.43	1.44	1.30	1.18
		c. Manufacture of solid fuels and other energy industries	kt-N_2O	0.07	0.10	0.05	0.11	0.29	0.28	0.23	0.21	0.16	0.14
	1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-N_2O	1.28	1.45	1.49	1.66	1.50	1.57	1.23	1.28	1.29	1.31
		b. Non-ferrous metals	kt-N_2O	0.23	0.21	0.18	0.07	0.05	0.04	0.05	0.05	0.05	0.04
		c. Chemicals	kt-N_2O	0.78	1.25	1.23	1.08	0.99	1.01	1.14	1.12	1.20	1.15
		d. Pulp, paper and print	kt-N_2O	0.51	0.94	0.96	1.00	1.20	1.18	1.20	1.21	1.27	1.30
		e. Food processing, beverages and tobacco	kt-N_2O	0.07	0.10	0.12	0.16	0.14	0.20	0.13	0.12	0.09	0.08
		f. Non-metallic minerals	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
		g. Other	kt-N_2O	1.78	2.13	2.67	2.76	2.28	2.23	2.28	2.35	2.35	2.17
	1.A.3. Transport	a. Domestic aviation	kt-N_2O	0.21	0.29	0.32	0.32	0.29	0.28	0.27	0.29	0.30	0.30
		b. Road transportation	kt-N_2O	11.60	12.77	12.41	8.53	6.54	6.11	5.74	5.35	5.08	4.94
		c. Railways	kt-N_2O	0.37	0.32	0.28	0.25	0.23	0.23	0.22	0.22	0.21	0.21
		d. Domestic Navigation	kt-N_2O	0.36	0.39	0.40	0.34	0.28	0.28	0.28	0.28	0.28	0.28
	1.A.4. Other sectors	a. Commercial/institutional	kt-N_2O	0.37	0.58	0.69	0.79	0.74	0.94	0.58	0.51	0.57	0.67
		b. Residential	kt-N_2O	0.29	0.33	0.34	0.33	0.27	0.28	0.27	0.27	0.25	0.24
		c. Agriculture/forestry/fishing	kt-N_2O	0.18	0.11	0.08	0.07	0.07	0.07	0.07	0.08	0.07	0.06
	1.A.5 Other	a. Stationary	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-N_2O	22.05	26.69	28.08	25.56	22.49	22.38	22.06	21.75	21.80	21.31
			kt-CO_2 eq.	6,570	7,955	8,368	7,617	6,701	6,671	6,575	6,481	6,497	6,350
Total of all gases			kt-CO_2 eq.	1,086,071	1,168,867	1,207,488	1,245,553	1,113,800	1,163,080	1,212,253	1,245,608	1,259,384	1,213,465

In FY2014, emissions from fuel combustion were 1,213,465 kt-CO_2 eq., which accounted for 89.0% of Japan's total GHG emissions (excluding LULUCF). As compared to FY1990, the emissions were increased by 11.7%, led by the increases in emissions from energy industries (1.A.1) by 50.8% (180,149 kt-CO_2 eq.) and from transport (1.A.3) by 2.9% (5,902 kt-CO_2 eq.). On the other hand, the emissions from manufacturing industries and construction (1.A.2) and other sectors (1.A.4) were decreased by 13.5% (51,462 kt-CO_2 eq.) and 4.9% (7,196 kt-CO_2 eq.), respectively. The major contributing factors for the rise in emissions from 1990 are the increase of fossil fuel consumptions accompanied by the rise in electricity consumption and in traffic demand of passenger cars. The decreases in emissions from manufacturing industries were mainly caused by the decrease of fuel consumption due to the drop of the production amount in recent years and the change of fuel type from liquid to gaseous.

GHG emissions from fuel combustion in FY2014 had decreased by 3.6% compared to FY2013. The primary reason for the emission decrease in FY2014 as compared to FY2013 was the decrease of CO_2 emissions from electric power generation in the energy industries.

3.2.1. Comparison of the Sectoral Approach with the Reference Approach

This chapter explains a comparison between reference approach and sectoral approach in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (Decision 24/CP.19 Annex I, paragraph 40). For the methodological issues of the sectoral approach, please refer to the section 3.2.4. b).

3.2.1.1. Methodological Issues of the Reference Approach

The reference approach is to calculate the CO_2 emissions from combustion, using a country's energy supply data. The CO_2 emissions estimated by the reference approach are not included in the national total and used for verification purpose. The CO_2 emissions by the reference approach are estimated by the following formula:

$$E = \sum_i \left[(A_i - N_i) \times GCV_i \times 10^{-3} \times EF_i \times OF_i \right] \times 44/12$$

E	: CO_2 emissions from fossil fuel combustion [t-CO_2]
A	: Apparent energy consumption [original unit (t, kl, $10^3 \times m^3$)]
N	: Non-energy use of fossil fuels [original unit]
GCV	: Gross calorific value [MJ/original unit]
EF	: Carbon content of the fuel [t-C/TJ]
OF	: Oxidation factor
i	: Type of fuel

The apparent energy consumptions A are estimated by the following formula:

Primary fuels: A = Production + Imports – Exports ± Stock change – International bunkers

Secondary fuels: A = Imports – Exports ± Stock change – International bunkers

Table 3-3 Sources of each term of reference approach estimation equation

Term	Source[2]
Production	Indigenously Produced (#110000) in Agency for Natural Resources and Energy's *General Energy Statistics* (Japan's Energy Balance Table)
Imports	Imported (#120000) in the statistics + International bunker fuels (see section 3.2.2.)
Exports	Export (#160000) in the statistics
Stock change	Stockpile Change / Supply (#170000) in the statistics
International bunkers	See section 3.2.2.
Non-energy use	Non-energy and feedstock use (#950000) in the statistics (section 3.2.3.)

The carbon contents of the fuels, the oxidation factors and the gross calorific values are in common with the sectoral approach (refer to the section 3.2.4. b).)

The details of estimation results by reference approach are shown in the Common Reporting Format (CRF) table 1.A(b). The correspondence between fuels of the *General Energy Statistics* and those of the table is shown in Annex 4.

- *Discrepancies between the figures reported in the CRF tables and the IEA statistics*

Some discrepancies exist between the fuel data of energy supply and demand in the CRF tables and the data of energy supply and demand reported in the International Energy Agency (IEA) statistics. Please refer to the details of discrepancies and their reasons in Annex 4 (A4.1).

3.2.1.2. Difference in Energy Consumption

As shown in Table 3-4, fluctuations of difference[3] of energy consumption between the reference approach and the sectoral approach during 1990-2014 range between -3.53% (FY2009) and -1.22% (FY2008).

Energy consumption from wastes used for energy and from the incineration of wastes with energy recovery is calculated in the sectoral approach in accordance with the *2006 IPCC Guidelines*.

The difference between those two approaches for solid fuels in 2008 was a large value (6.39%), while the difference in 2009 was minus (-0.57%). It means that, in 2008, the coal on the consumer side (imported steam coal [$130[4]]) was not fully consumed and built stocks due to the effect of the Global Financial Crisis in 2008; therefore, the large difference occurred between the reference approach estimated from provider side and the sectoral approach estimated from consumer side in 2008. It also means that the stocked coal has conversely been drawn down and consumed in 2009; therefore, the difference between those two approaches became minus. It should be noted that the stock changes explained here are not from provider side but from consumer side.

[2] Numbers with # indicate the corresponding sector (row) numbers in the *General Energy Statistics* (Japan's Energy Balance Table).

[3] Difference = [(Reference approach)-(Sectoral approach)]/(Sectoral approach)

[4] Numbers with $ indicate the corresponding energy source (column) numbers in the *General Energy Statistics* (Japan's Energy Balance Table)

Table 3-4 Comparison of energy consumption

[10^{15}J]

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Reference Approach													
Liquid fuels	9,545	10,129	9,433	8,923	8,375	8,419	7,778	7,119	7,133	7,507	7,593	7,406	6,757
Solid fuels	3,314	3,641	4,204	4,763	4,823	5,037	4,920	4,384	4,982	4,654	4,862	5,278	5,117
Gaseous fuels	2,088	2,527	3,125	3,378	3,743	4,080	4,013	3,983	4,226	4,920	5,090	5,067	5,046
Other fossil fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total RA	**14,947**	**16,296**	**16,762**	**17,064**	**16,941**	**17,536**	**16,710**	**15,486**	**16,341**	**17,081**	**17,545**	**17,751**	**16,920**
Sectoral Approach													
Liquid fuels	9,467	9,980	9,449	8,946	8,427	8,439	7,763	7,150	7,249	7,705	7,796	7,512	6,784
Solid fuels	3,316	3,605	4,098	4,801	4,790	4,958	4,625	4,409	4,742	4,550	4,738	5,092	5,068
Gaseous fuels	2,273	2,728	3,286	3,457	3,807	4,167	4,072	4,056	4,288	4,980	5,169	5,128	5,151
Other fossil fuels	281	318	372	456	458	469	456	438	442	441	462	450	447
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total	**15,338**	**16,629**	**17,205**	**17,661**	**17,482**	**18,032**	**16,917**	**16,052**	**16,721**	**17,676**	**18,165**	**18,182**	**17,451**
Difference (%)													
Liquid fuels	0.82%	1.50%	-0.17%	-0.26%	-0.62%	-0.24%	0.19%	-0.43%	-1.60%	-2.57%	-2.61%	-1.41%	-0.40%
Solid fuels	-0.06%	1.00%	2.58%	-0.79%	0.70%	1.59%	6.39%	-0.57%	5.05%	2.30%	2.62%	3.65%	0.95%
Gaseous fuels	-8.15%	-7.37%	-4.89%	-2.30%	-1.69%	-2.08%	-1.47%	-1.80%	-1.44%	-1.21%	-1.54%	-1.19%	-2.03%
Other fossil fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total	**-2.55%**	**-2.00%**	**-2.57%**	**-3.38%**	**-3.10%**	**-2.75%**	**-1.22%**	**-3.53%**	**-2.28%**	**-3.36%**	**-3.41%**	**-2.37%**	**-3.04%**

3.2.1.3. Difference in CO_2 Emissions

As shown in Table 3-5, fluctuations of a difference of CO_2 emissions between the reference approach and the sectoral approach during 1990-2014 range between -1.77% (FY2014) and 1.88% (FY2008).

Emissions from wastes used for energy and from the incineration of wastes with energy recovery are not reported in waste incineration (5.C.) but reported in fuel combustion (1.A.) in accordance with the *2006 IPCC Guidelines*.

The difference between both approaches for solid fuels in 2008 was a large value (5.31%), while the difference in 2009 was minus (-1.75%). It is because of the same reason as the difference of energy consumption which is described in the previous page.

Table 3-5 Comparison of CO_2 emissions

[Mt-CO_2]

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Reference Approach													
Liquid fuels	661.3	701.7	655.5	621.3	583.0	586.9	545.3	497.1	498.6	521.8	529.5	512.9	466.6
Solid fuels	296.2	325.3	378.7	429.6	435.0	454.5	443.3	395.3	449.5	419.2	438.0	472.5	459.2
Gaseous fuels	105.7	128.1	158.4	171.1	189.8	206.8	203.4	201.8	214.0	248.9	257.4	254.8	258.2
Other fossil fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total RA	**1,063**	**1,155**	**1,193**	**1,222**	**1,208**	**1,248**	**1,192**	**1,094**	**1,162**	**1,190**	**1,225**	**1,240**	**1,184**
Sectoral Approach													
Liquid fuels	644.7	677.7	640.4	605.9	569.1	571.1	525.1	481.8	488.2	520.4	526.9	510.8	461.4
Solid fuels	306.0	329.4	374.4	437.4	437.1	452.0	421.0	402.4	432.1	414.3	431.4	464.3	463.3
Gaseous fuels	116.5	140.0	167.8	176.1	194.1	211.9	207.5	206.2	218.8	253.9	262.6	260.2	264.9
Other fossil fuels	10.8	12.4	15.2	17.0	16.0	16.7	16.4	15.3	15.2	15.3	16.4	15.9	15.9
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total	**1,078**	**1,159**	**1,198**	**1,236**	**1,216**	**1,252**	**1,170**	**1,106**	**1,154**	**1,204**	**1,237**	**1,251**	**1,205**
Difference (%)													
Liquid fuels	2.57%	3.54%	2.37%	2.55%	2.44%	2.77%	3.84%	3.18%	2.13%	0.27%	0.49%	0.42%	1.12%
Solid fuels	-3.19%	-1.22%	1.13%	-1.79%	-0.49%	0.56%	5.31%	-1.75%	4.03%	1.19%	1.53%	1.77%	-0.88%
Gaseous fuels	-9.26%	-8.50%	-5.63%	-2.84%	-2.24%	-2.40%	-2.00%	-2.15%	-2.19%	-2.00%	-1.98%	-2.09%	-2.51%
Other fossil fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Total	**-1.38%**	**-0.37%**	**-0.44%**	**-1.16%**	**-0.71%**	**-0.28%**	**1.88%**	**-1.03%**	**0.67%**	**-1.17%**	**-1.00%**	**-0.87%**	**-1.77%**

3.2.1.4. Comparison between Differences in Energy Consumption and that of CO_2 Emissions

The difference in energy consumption and the difference in CO_2 emissions generally show a similar tendency for their trends.

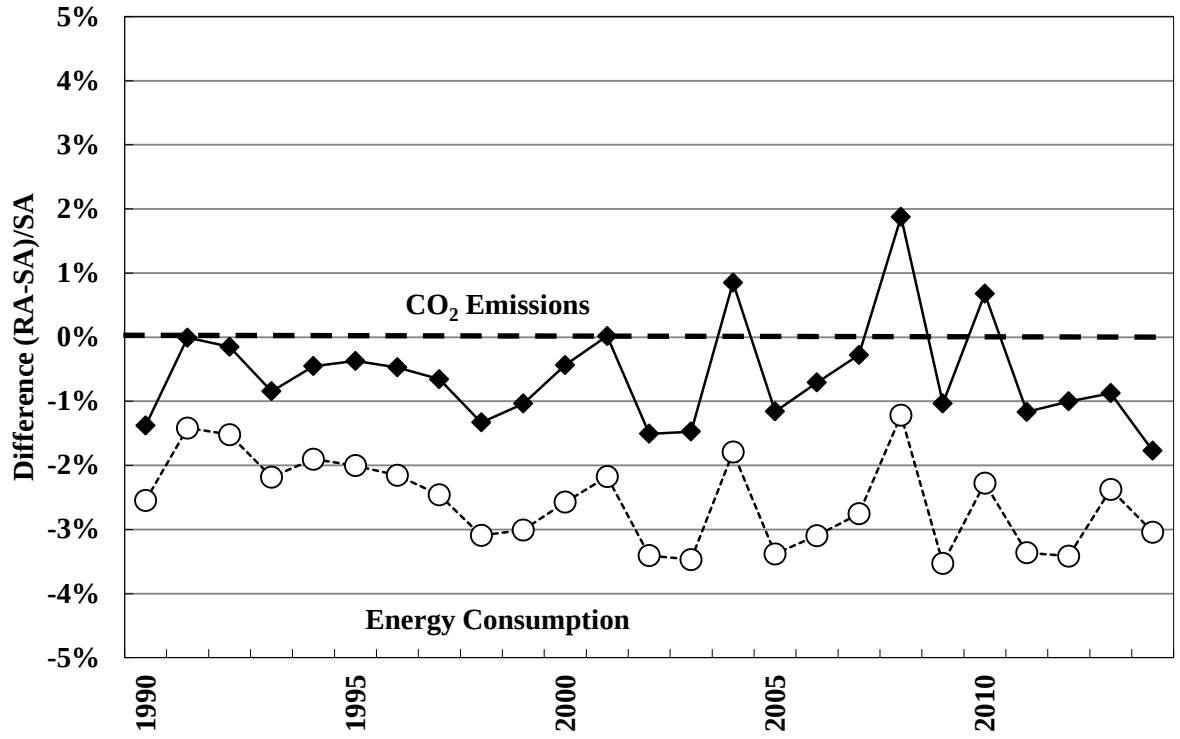


Figure 3-1 Trends in difference of energy consumption and CO_2 emissions

3.2.1.5. Causes of the difference between Reference Approach and Sectoral Approach

The difference in energy consumption and in CO_2 emissions can be explained by the difference of the amount of carbon which were deducted as feedstock and non-energy use in each approach, and 'coal blending' [#211000], 'oil product blending' [#221000], 'coal products secondary transformation' [#281000], 'oil products secondary transformation' [#282000], 'other transformation' [#289000], 'transformation and consumption stockpile change' [#350000], and 'statistical discrepancy' [#400000] of the Energy Balance Table (*General Energy Statistics*).

1) Matters not sufficiently considered in the calculation process of Reference Approach

In the current estimation of reference approach, the energy consumption amount, which is obtained by subtracting the amount of non-energy use from the amount supplied inside the country, is assumed to be completely combusted. However, in real situation, some of the energy amount is not combusted but stored, and the increase or decrease of the stored amount is not reflected in reference approach.

- ***Other Transformation [#289000]***

In Energy transformation & own use sector such as oil refining, energy source shipment/drawdown amounts do not necessarily match production/receipt amounts. Other than energy received through one's own imports or that produced by refining, factors involved include returns from consumption/sales sectors of products once shipped, transactions of small amounts of byproduct energy from other companies, stock buildups and drawdowns due to product storage tank installation or decommissioning at factories and business sites, and losses due to accidents or fires.

When energy source inconsistencies due to such causes in the Energy transformation & own use sector are determined, the other input/output sector accounts for its amount. However, this input/output are not reflected in reference approach emission calculation.

- ***Transformation and Consumption Stockpile Change [#350000]***

This sector accounts for the increase or decrease of stock in Energy transformation & own use sector and Final energy consumption sector. However, this increase/decrease was not reflected in reference approach emission calculation.

CO_2 emissions from wastes used for energy and from the incineration of wastes with energy recovery originated from carbon in waste oil, waste plastics, waste tire, synthetic textile scrap and other non-biogenic waste which were incinerated. These amounts of carbons may not be reflecting the actual conditions in the deduction of carbon for feedstock and non-energy use in the calculation of the reference approach. The methodology for calculating the amount of stored carbon as feedstock and non-energy use in the reference approach should be examined and revised in the future. In addition, some emissions are not calculated for the sources that the emissions are relatively low compared to total emissions in reference approach, in order not to be too complicated. For example, the emissions from lubricants used in two stroke engines are not accounted for in the reference approach emission calculation.

2) Matters which cannot be avoided for the characteristics of survey data

- ***Supply Side Discrepancy [#401000]***

Statistical discrepancy is originally the intrinsic error arising at the sampling stage in statistical studies (source error), and mutual discrepancies among the statistics for supply, conversion, and consumption. It is sometimes difficult to guess where the discrepancies come from (relative error).

These errors induce the discrepancies among domestic supply, conversion, and final energy consumption, calculated as difference between both approaches.

3) Matters related to the difference of energy and carbon balance between energy input and output

- ***'Coal Blending' [#211000], 'Oil Product Blending' [#221000], 'Coal Products Secondary Transformation' [#281000], 'Oil Products Secondary Transformation' [#282000]***

This sector represents energy conversion that does not belong to any of the sectors from Coke production [#212000] to Steel process gas [#215000] and from Oil refinery [#222000] to District heat supply [#270000], and actions considered to be energy conversion in which coal or oil product brands are changed by only simple operations such as blending or moisture adjustment.

Carbon weight is considered to be consistent before and after blending or conversions. However, given that carbon content per calorific value is changed following such as blending, in statistics, carbon weight could be varied before and after blending or conversions. This difference can generate the variation between two approaches.

4) Matters related to the conversion to another fuel type

- ***'Gas Conversion and Production' [#231000]***

This sector represents energy conversion arising from town gas production. Town gas is made from liquid and solid fuels such as liquefied petroleum gas (LPG) and coke oven gas (COG) as well as gaseous fuels such as liquefied natural gas (LNG). Thus, the fact that some liquid and solid fuels are converted to gaseous fuels is not reflected in reference approach emission calculation. The emissions calculated by the sectoral approach tend to be larger than those by reference approach for gaseous fuels and smaller for liquid and solid fuels. This sector does not affect the difference between two approaches in total.

Table 3-6 Comparison of CO_2 emissions (detail)

[kt-CO_2]

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
RA	**1,063,223**	**1,155,141**	**1,192,566**	**1,222,112**	**1,207,770**	**1,248,233**	**1,191,967**	**1,094,214**	**1,162,130**	**1,189,899**	**1,224,985**	**1,240,236**	**1,184,026**
Liquid fuels	661,288	701,744	655,537	621,345	583,023	586,944	545,283	497,136	498,638	521,829	529,526	512,926	466,592
Solid fuels	296,193	325,346	378,657	429,633	434,955	454,474	443,315	395,316	449,456	419,218	438,020	472,510	459,216
Gaseous fuels	105,741	128,051	158,372	171,134	189,793	206,814	203,368	201,763	214,036	248,852	257,439	254,800	258,218
Other fossil fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
SA	**1,078,082**	**1,159,452**	**1,197,784**	**1,236,463**	**1,216,394**	**1,251,734**	**1,170,017**	**1,105,649**	**1,154,339**	**1,203,959**	**1,237,398**	**1,251,180**	**1,205,408**
Liquid fuels	644,730	677,734	640,355	605,901	569,135	571,149	525,131	481,800	488,214	520,447	526,948	510,800	461,428
Solid fuels	305,968	329,370	374,429	437,445	437,076	451,963	420,978	402,354	432,060	414,290	431,427	464,277	463,276
Gaseous fuels	116,536	139,951	167,825	176,128	194,146	211,905	207,523	206,203	218,823	253,920	262,639	260,226	264,853
Other fossil fuels	10,849	12,398	15,175	16,989	16,037	16,717	16,386	15,292	15,241	15,301	16,385	15,877	15,851
Peat	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
RA-SA	**-14,859**	**-4,311**	**-5,218**	**-14,350**	**-8,624**	**-3,501**	**21,949**	**-11,435**	**7,791**	**-14,060**	**-12,413**	**-10,943**	**-21,382**
Liquid fuels	16,559	24,010	15,182	15,445	13,888	15,795	20,153	15,336	10,423	1,382	2,578	2,127	5,164
Solid fuels	-9,774	-4,024	4,228	-7,812	-2,121	2,511	22,337	-7,038	17,395	4,928	6,594	8,233	-4,060
Gaseous fuels	-10,795	-11,899	-9,454	-4,994	-4,353	-5,091	-4,155	-4,440	-4,786	-5,069	-5,199	-5,426	-6,635
Other fossil fuels	-10,849	-12,398	-15,175	-16,989	-16,037	-16,717	-16,386	-15,292	-15,241	-15,301	-16,385	-15,877	-15,851
Peat	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Supply side discrepancy	**-7,573**	**3,811**	**3,792**	**-3,509**	**7,320**	**7,501**	**12,286**	**5,040**	**16,920**	**4,283**	**8,773**	**8,496**	**8,496**
Liquid fuels	1,422	7,210	835	481	875	622	534	403	-1,108	-1,030	-441	894	894
Solid fuels	-8,995	-3,399	2,956	-3,989	6,444	6,879	11,752	4,637	18,354	6,327	10,201	8,818	8,818
Gaseous fuels	0	0	0	0	0	0	0	0	-326	-1,014	-987	-1,216	-1,216
Coal blending	**260**	**410**	**508**	**-1,058**	**-1,131**	**-1,361**	**-1,044**	**-901**	**-1,284**	**-1,589**	**-1,801**	**-1,900**	**-1,900**
Liquid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid fuels	260	410	508	-1,058	-1,131	-1,361	-1,044	-901	-1,284	-1,589	-1,801	-1,900	-1,900
Gaseous fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil product blending	**-2,041**	**-493**	**168**	**374**	**208**	**163**	**235**	**-34**	**70**	**46**	**-72**	**-1,423**	**-1,423**
Liquid fuels	-2,041	-493	168	374	208	163	235	-34	70	46	-72	-1,423	-1,423
Solid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaseous fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Coal products secondary transformation	**-41**	**-24**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Liquid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Solid fuels	-41	-24	0	0	0	0	0	0	0	0	0	0	0
Gaseous fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Oil products secondary transformation	**1,247**	**506**	**605**	**791**	**-34**	**-299**	**64**	**266**	**1,750**	**1,487**	**1,734**	**1,469**	**1,469**
Liquid fuels	1,247	506	605	791	-34	-299	64	266	1,750	1,487	1,734	1,469	1,469
Solid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaseous fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Gas conversion and production	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Liquid fuels	9,743	10,918	8,987	5,914	4,442	4,351	4,108	3,870	4,096	4,326	4,370	4,451	4,451
Solid fuels	773	492	386	80	0	0	0	0	0	0	0	0	0
Gaseous fuels	-10,516	-11,410	-9,373	-5,994	-4,442	-4,351	-4,108	-3,870	-4,097	-4,327	-4,370	-4,451	-4,451
Other transformation	**-535**	**-635**	**2,139**	**2,786**	**-1,318**	**1,156**	**1,450**	**1,479**	**2,608**	**-3,943**	**-5,653**	**-1,234**	**-1,234**
Liquid fuels	-535	-635	2,139	2,786	-1,318	1,156	1,450	1,479	2,608	-3,943	-5,653	-1,234	-1,234
Solid fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Gaseous fuels	0	0	0	0	0	0	0	0	0	0	0	0	0
Transformation and consumption stockpile change	**1,491**	**1,894**	**2,319**	**599**	**-2,636**	**-2,826**	**15,834**	**-9,685**	**2,717**	**1,337**	**2,822**	**1,249**	**1,249**
Liquid fuels	828	1,332	-889	278	2,424	-1,368	1,751	-741	427	-919	2,573	-2,942	-2,942
Solid fuels	681	757	2,934	-1,097	-5,555	-1,106	13,756	-8,629	2,370	1,707	-192	3,671	3,671
Gaseous fuels	-18	-195	275	1,419	495	-353	327	-315	-80	550	441	520	520
Total	**-7,192**	**5,470**	**9,531**	**-15**	**2,408**	**4,333**	**28,825**	**-3,834**	**22,782**	**1,620**	**5,803**	**6,657**	**6,657**
Liquid fuels	10,664	18,840	11,845	10,625	6,598	4,625	8,142	5,243	7,845	-34	2,511	1,216	1,216
Solid fuels	-7,322	-1,764	6,784	-6,064	-242	4,412	24,465	-4,892	19,440	6,445	8,208	10,588	10,588
Gaseous fuels	-10,534	-11,606	-9,099	-4,576	-3,948	-4,704	-3,781	-4,186	-4,502	-4,790	-4,916	-5,147	-5,147
(RA-SA)-(Total)	**-7,667**	**-9,782**	**-14,749**	**-14,335**	**-11,032**	**-7,834**	**-6,875**	**-7,600**	**-14,991**	**-15,680**	**-18,216**	**-17,600**	**-28,039**
Liquid fuels	5,894	5,170	3,337	4,820	7,290	11,170	12,011	10,093	2,579	1,416	66	911	3,949
Solid fuels	-2,452	-2,260	-2,556	-1,748	-1,879	-1,901	-2,127	-2,146	-2,045	-1,517	-1,615	-2,355	-14,648
Gaseous fuels	-261	-294	-355	-418	-406	-387	-373	-255	-284	-278	-283	-279	-1,488
Other fossil fuels	-10,849	-12,398	-15,175	-16,989	-16,037	-16,717	-16,386	-15,292	-15,241	-15,301	-16,385	-15,877	-15,851

3.2.2. International Bunker Fuels

a) Category Description

This sector provides the estimation methods for determining CO_2, CH_4, and N_2O emissions from the fuel consumed for international navigation and aviation.

The emissions from bunker fuels used for international navigation and aviation are not included in the national totals but are reported as the memo item in the CRFs in accordance with the *UNFCCC reporting guidelines* and the *2006 IPCC Guidelines*.

b) Methodological Issues

- ***Estimation Method***

The emissions of CO_2, CH_4 and N_2O from this source are derived by multiplying the consumption of

each fuel type handled by bonds by the emission factor.

- ***Emission Factors***

➢ *CO_2*

The emission factors used for CO_2 are the same as those from fuel combustion (CO_2) in the energy sectors (Refer to Section 3.2.4. b)).

On the annual review on 2012 (FCCC/ARR/2012/JPN) and 2013 (FCCC/ARR/2013/JPN), the ERT noted that the Japanese carbon emission factor (EF) for jet kerosene (18.3 t-C/TJ based on the gross calorific value) is lower than the EF for jet kerosene included in the *IPCC Guidelines* (18.5 t-C/TJ based on the gross calorific value). The ERT recommended that Japan provide additional information.

The Japanese carbon emission factor for jet kerosene is obtained from actual measurement. In addition, the 95% confidence interval of EF for jet kerosene is 18.1-19.3 t-C/TJ (based on the gross calorific value) in the *2006 IPCC Guidelines* and the Japanese EF is inside the range. Therefore, Japan considers that this country-specific EF is appropriate value, comparing to the default value.

➢ *CH_4, N_2O*

The default values given in the *2006 IPCC Guidelines* are used for CH_4 and N_2O emission factors.

Table 3-7 Emission factors for CH_4 and N_2O from international bunkers

Transport mode	Type of fuel	CH_4 emission factor	N_2O emission factor
Aircraft	Jet fuel	0.5 [kg-CH_4/TJ] [a]	2 [kg-N_2O/TJ] [a]
Shipping	Fuel oil A, fuel oil B, fuel oil C, diesel oil, kerosene	7 [kg-CH_4/TJ] [b]	2 [kg-N_2O/TJ] [b]

a. *2006 IPCC Guidelines* Vol. 2, Table 3.6.5
b. *2006 IPCC Guidelines* Vol. 2, Table 3.5.3. According to the *2006 IPCC Guidelines* Vol. 3 page 5.7, CH_4 and N_2O emissions from lubricants are very small in comparison to CO_2, and these can be neglected for the greenhouse gas calculation. Therefore, the emissions are not estimated.

- ***Activity Data***

The totals for bonded imports and bonded exports given in the Ministry of Economy, Trade and Industry's *Yearbook of Mineral Resources and Petroleum Products Statistics* (former *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*) are used for the emissions of CO_2, CH_4, and N_2O from the relevant source.

A and B in the diagram below correspond to the items under bonded exports and bonded imports, respectively, in the *Yearbook of Mineral Resources and Petroleum Products Statistics* (former *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*). C equals to the sum of A and B and it is used as the activity data for this source of emissions. This is considered to be approximately equivalent to the amount of the fuels sold in Japan for international aviation and navigation.

It is assumed that jet fuel is used by aircraft, while fuel oil A, B, C, diesel oil, kerosene and lubricants are used by vessels. Fuel oil A, B, and C are used for the propulsion of international water-borne vessels. Diesel oil and kerosene are used only for fuels of private power generators (e.g. air heating). All lubricants are assumed to be oxidized during use from the viewpoint of conservativeness as lubricants consumption by type is unknown.

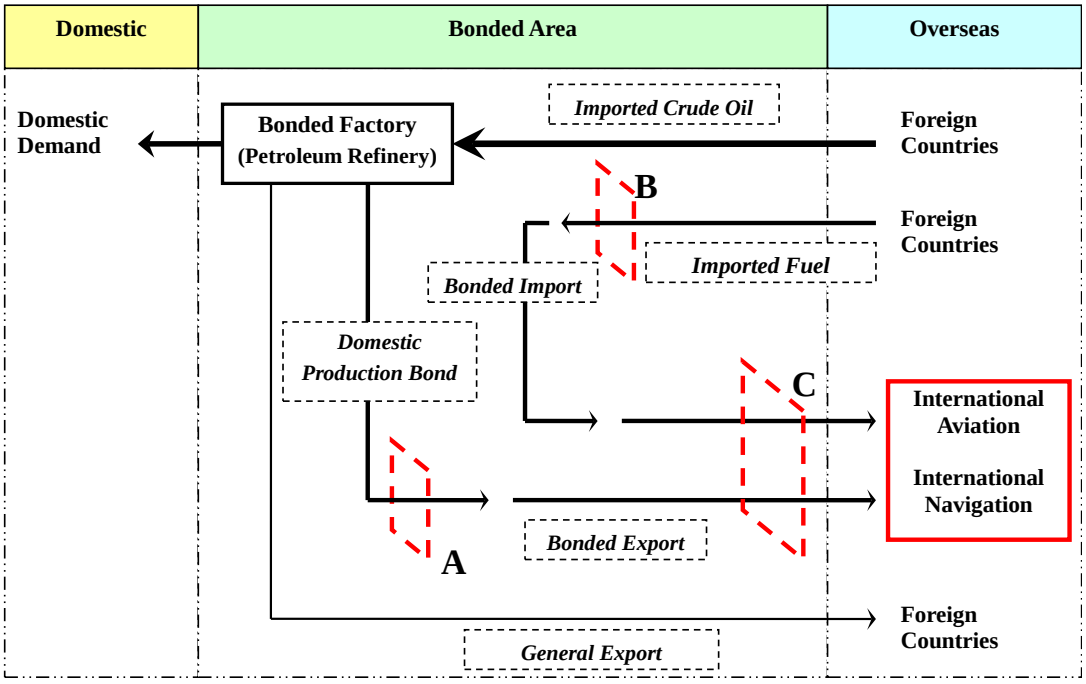


Figure 3-2 Activity data for international bunkers

- CO_2

The kiloliter-based consumption data given in the Ministry of Economy, Trade and Industry's *Yearbook of Mineral Resources and Petroleum Products Statistics* (former *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*) are converted to Joule-based data using the actual calorific values given in the *General Energy Statistics* by the Agency for Natural Resources and Energy.

- CH_4, N_2O

The *2006 IPCC Guidelines* provide default emission factors that are based on net calorific values. Therefore, the activity data in gross calorific values are converted to net calorific values by multiplying them by the conversion rate.

Glossary

Bonded Jet Fuel

Under the Tariff Law, aircraft (Japanese and non-Japanese) flying international routes are deemed to be "aircraft for international use", and the fuel they consume is tariff-free, subject to the completion of the required procedures. The application of this legislation means that if fuel is refined from crude oil imported to Japanese refinery, both the crude oil import tariff and the petroleum and coal tax are waived. Similarly, if fuel has been imported as a product, the product import tariff is waived. The foregoing is termed as "bonded jet fuel".

Bonded Fuel Oil

Vessels that ply between Japan and other countries are deemed to be "foreign trade vessels", under the Tariff Law. The majority of their fuel is consumed outside Japanese territorial waters, and, therefore, both the tariffs and the petroleum and coal tax are waived. The foregoing is termed as "bonded fuel oil".

Bonded Export

The demand for fuel supplied to aircraft (Japanese and non-Japanese) flying international routes and ships (Japanese and non-Japanese) that ply foreign ocean routes is termed as “bonded demand”. Jet fuel is supplied to aircraft while fuel oil is supplied to ships. Of these bonded demands, the fuel supplied from products that was produced from crude oil is counted as bonded export by the Ministry of Economy, Trade and Industry.

Bonded Import (Bond to Bond)

Fuel products that are imported from foreign countries, landed in a bonded area and supplied from the bonded area to bonded demand without going through domestic customs, is counted as bonded import by the Ministry of Economy, Trade and Industry.

3.2.3. Feedstocks and Non-Energy Use of Fuels

In the method used to estimate GHG emissions from fuel combustion (1.A.), the energy consumption in the category of Non-energy and feedstock use (#950000) which is used as feedstocks without the combustion and oxidation process was deducted from the Total energy consumption (#500000) in the *General Energy Statistics*, because the total energy consumption includes the amount of energy used as feedstocks without the combustion and oxidation process.

The consumption in this category includes the following: (1) Consumption which can be confirmed as clearly non-energy uses by official statistics, such as surveys of feedstock inputs according to the *Current Survey of Energy Consumption* which is the data source of the *General Energy Statistics*; and (2) Amount of products which are produced for the purpose of non-energy use from the beginning. (However, the portion which is confirmed from official statistics such as the *Current Survey of Energy Consumption* as having been employed for energy uses is treated as energy consumption and is excluded from non-energy use.)

The feedstocks and non-energy use of fuels are reported in the Common Reporting Format (CRF) table 1.A(d). The correspondence between fuels of the *General Energy Statistics* and those of the table is shown in Annex 4.

The CO_2 emissions from combustion or oxidation of the fuel used for non-energy purpose such as feedstock use of products in any process of manufacturing, use and abandonment of products are separately reported in the following sectors. (For detail, see each related chapter.)

Table 3-8 Allocated CO_2 emissions from fuel used for non-energy purpose such as feedstock

CO_2 emitting process	CRF Category	Type of fuel used for non-energy purpose such as feedstock	Emission factor	
				Calorific value
Ammonia production	2.B.1	Naphtha	See Table 3-10	See Table 3-17
		Liquefied petroleum gas (LPG), (until FY2002) [1)]		
		Refinery gas (off-gas)		
		Indigenous natural gas		
		Coal (steam coal, imports)		
		Petroleum coke		
		Liquefied natural gas (LNG)		
		Coke oven gas (COG) (until FY2001)		
Silicon carbide production	2.B.5	Petroleum coke	2.3 [t-CO_2/t] (per petroleum coke consumption amount)	
Calcium carbide production	2.B.5	Petroleum coke	From reducing agent in production: 1.09 [t-CO_2/t] (confidential information in and after FY2008), from use: 1.10 [t-CO_2/t] (both EFs per calcium carbide production amount)	
Ethylene production	2.B.8	Naphtha	Confidential information	
Use of electric arc furnaces in steel production	2.C.1	Petroleum coke	Estimated from carbon electrodes consumption amount	
Automobile and marine engine oils (excluding total loss type) [1)]	2.D.1	Lubricants	See Table 3-10	
Paraffin wax use	2.D.2	Bitumen	See Table 3-10	
Waste incineration	5.C	Lubricants, bitumen, naphtha, LPG, etc.	Industrial waste oil: 2,933 [kg-CO_2/t (wet)], industrial waste plastic: 2,567 [kg-CO_2/t (wet)], municipal waste plastic: 2,754 [kg-CO_2/t (dry)] (all EFs per waste amount burned)	
Emissions from the decomposition of petroleum-derived surfactants	5.E	Naphtha, etc.	Synthetic alcohol: 2,839 [kg-CO_2/t], alkyl benzene: 3,220 [kg-CO_2/t], alkyl phenol: 3,000 [kg-CO_2/t], ethylene oxide: 2,000 [kg-CO_2/t], (all EFs per surfactant decomposition amount)	

1) CO_2 emissions from automobile and marine engine oils (total loss type) are included in Transport (1.A.3).

Among emissions from manufacturing processes of iron and steel and non-ferrous metals, emissions from fuel combustion should be reported in Energy sector (1.A) and emissions from reducing agent should be reported in Industrial processes and product use sector (2.C). Both emissions are reported together in Energy sector (1.A), because Japan considers that it is the most appropriate to grasp all emissions from manufacturing processes of iron and steel, and non-ferrous metals comprehensively from the viewpoints of accuracy, and avoiding double-counting and omissions. Each manufacturing process and category is shown in Table 3-9.

Table 3-9 Reported category of CO_2 emissions from iron and steel and non-ferrous metals process

CO_2 emitting process	CRF Category	Type of fuel used for non-energy purpose such as feedstock	Reported category in Energy Sector
Iron and steel roduction, Pig iron, Direct reduced iron, Sinter, Pellet	2.C.1	Coke	1.A.2.a (Iron and steel)
Ferroalloys production	2.C.2	Coke	1.A.2.a (Iron and steel)
Aluminium production	2.C.3	Coke	1.A.2.b (Non-ferrous metals)
Lead production	2.C.5	Coke	1.A.2.b (Non-ferrous metals)
Zinc production	2.C.6	Coke	1.A.2.b (Non-ferrous metals)

3.2.4. CO_2 Emissions from Energy Industries (1.A.1.:CO_2)

a) Category Description

This source category provides the methods for estimating CO_2 emissions from public electricity and heat production (1.A.1.a), petroleum refining (1.A.1.b), and manufacture of solid fuels and other energy industries (1.A.1.c).

In FY2014, CO_2 emissions from this category accounted for 531,711 kt-CO_2, and represented 39.0% of Japan's total GHG emissions (excluding LULUCF). Public electricity and heat production (1.A.1.a) accounts for 88.5% and is the largest subcategory in energy industries (1.A.1).

The CO_2 emissions from the energy industries (1.A.1) change due to amount of power generation, share of thermal power generation, thermal efficiency and so on. CO_2 emissions from public electricity and heat production (1.A.1.a), which is the largest source in the energy industries (1.A.1), are considered to have a moderate correlation with the amount of power generation[5]. From FY1995 to FY1998, CO_2 emissions were decreased due to a decrease in the share of thermal power generation, while power generation was increased. From FY2011 to FY2013, CO_2 emissions were increased due to an increase in the share of thermal power generation, while power generation was decreased.

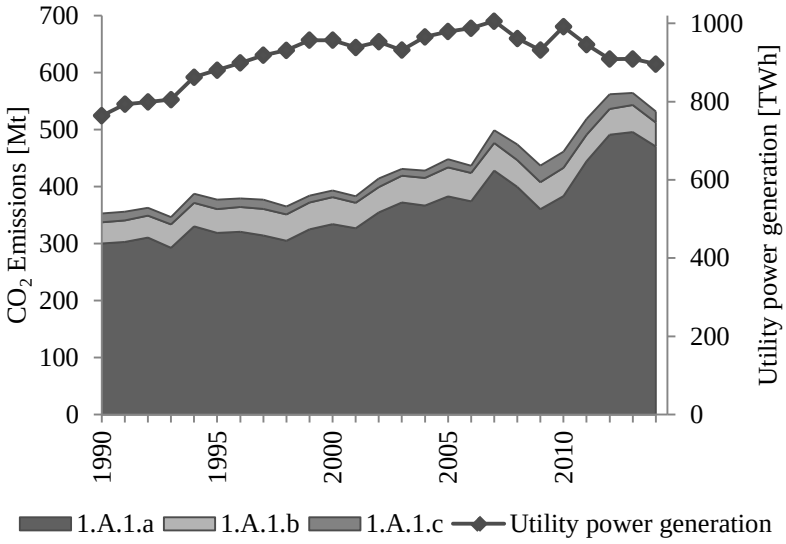


Figure 3-3 The trends of CO_2 emissions from Energy Industries (1.A.1) and related indicator

The IEFs (Implied Emission Factor) of CO_2 emissions from solid fuels in 1.A.1.c (Manufacture of solid fuels and other energy industries) have been pulled up and down by fluctuation of carbon balances derived from the transformation of solid fuels by the manufacture of solid fuels. The apparent annual change of this category is caused by the mass-balance, energy-balance and carbon-balance between coking coal, coke and other coal products, and may be influenced by statistical error, unobserved stockpiles in the process and/or spontaneous input-output unbalance.

b) Methodological Issues

- ***Estimation Method***

The Tier 2 Sectoral Approach has been used in accordance with the decision tree of the *2006 IPCC*

[5] Utility power generation (estimated from the *General Energy Statistics*, Agency for Natural Resources and Energy)

Guidelines to calculate emissions (Vol.2, Page 1.9, Fig. 1.2). Country-specific emission factors are used for all types of fuel.

$$E = \sum_{ij} \left[(A_{ij} - N_{ij}) \times GCV_i \times 10^{-3} \times EF_i \times OF_i \right] \times 44/12$$

E	: CO_2 emissions from fossil fuel combustion [t-CO_2]
A	: Energy consumption [original unit (t, kl, $10^3 \times m^3$)]
N	: Non-energy use of fossil fuels [original unit]
GCV	: Gross calorific value [MJ/original unit]
EF	: Carbon content of the fuel [t-C/TJ]
OF	: Oxidation factor
i	: Type of fuel
j	: Sector

The energy consumption and emissions from waste incineration with energy recovery are reported in fuel combustion (1.A.) as "other fossil fuels" and "biomass" in accordance with the *2006 IPCC Guidelines*.

The estimation method, emission factors and activity data for emissions from waste incineration with energy recovery are the same as those used in the waste incineration (5.C.) in accordance with the *2006 IPCC Guidelines*. Please refer to Chapter 7 for further details on the estimation methods.

The CO_2 emissions from biomass are not included in the national totals but are reported in the CRFs as reference in accordance with the *2006 IPCC Guidelines*.

CO_2 generated from an oil refinery plant was captured and stored from fiscal year 2004 to 2007, and it is reported under "CO_2 amount captured" in liquid fuels of 1.A.1.b Petroleum refining of the CRF table 1.A(a). It is subtracted from the emissions estimated by the above formula. Please refer to the section 3.4.3. for details.

- ***Emission Factors***

➢ *Carbon emission factors*

The carbon content of fuels expressed as the unit of gross calorific value (higher heating value) was used for carbon emission factors. The emission factors are country-specific values except for a part of fuels where the default value provided in the *2006 IPCC Guidelines* was applied.

The emission factors were developed based on three different concepts; (a) Energy sources other than Blast Furnace Gas (BFG) and Town gas, (b) BFG, and (c) Town gas.

Table 3-10 provides the emission factors for CO_2 by fuel types.

Table 3-10 Carbon emission factors for fuel combustion in gross calorific value (Unit: t-C/TJ)

Fuel			Code [1)]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Coal	Steel making coal		$110	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.6	24.6
	Coking coal		$111	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.4	24.4
	Pulverized coal injection (PCI) coal		$112	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	25.1	25.1
	Imported steam coal		$130	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.4	24.4
	Imported steam coal for general use		$131	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.4	24.4
	Imported steam coal for power generation use		$132	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.4	24.4
	Indigenous produced steam coal		$135	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	23.7	23.7
	Hard coal, anthracite & lignite		$140	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.9	25.9
Coal Products	Coke		$161	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	30.2	30.2
	Coal tar		$162	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9
	Coal briquette		$163	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	25.9	25.9
	Coke oven gas		$171	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.9	10.9
	Blast furnace gas		$172	27.2	26.9	26.7	26.5	26.4	26.4	26.5	26.5	26.4	26.3	26.2	26.6	26.6
	Converter furnace gas		$175	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	41.7	41.7
Oil	Crude oil for refinery use		$210	19.1	19.0	19.0	19.1	19.1	19.1	19.1	19.0	19.1	19.1	19.1	19.0	18.9
	Crude oil for refinery use		$211	19.1	19.0	19.0	19.1	19.1	19.1	19.1	19.0	19.1	19.1	19.1	19.0	18.9
	Residual and straight run fuel oil for refinery use		$214	21.3	21.4	21.4	21.4	21.5	21.5	21.5	21.4	21.4	21.5	21.5	19.7	19.5
	Crude oil for power generation use		$220	19.1	19.1	19.2	19.6	19.3	19.2	19.2	19.3	19.2	19.1	19.1	19.2	19.2
	Bituminous mixture fuel		$221	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
	Natural gas liquid (NGL) & condensate		$230	16.1	16.7	17.5	18.2	18.2	18.0	19.4	18.4	18.4	17.3	18.3	18.3	18.2
	NGL&condensate for refinery use		$231	17.4	18.1	18.0	18.3	18.2	18.1	19.4	18.4	18.4	17.3	18.4	18.3	18.2
	NGL&condensate for power generation use		$232	17.5	17.6	17.6	18.2	17.8	17.8	19.0	17.9	17.9	17.9	17.9	18.2	18.2
	NGL&condensate for petrochemical use		$233	15.6	16.2	16.8	17.6	17.7	17.1	18.8	17.9	18.0	16.9	18.2	18.3	18.2
Oil Products		Pure naphtha	$281	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.6	18.6
		Reformed feedstock Oil	$282	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	19.3	19.3
	Fuel oil	Gasoline	$310	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.7	18.7
		Jet fuel oil	$320	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.6	18.6
		Kerosene	$330	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.7	18.7
		Gas oil or diesel oil	$340	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.8	18.8
		Fuel oil A	$351	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	19.3	19.3
		Fuel oil C	$355	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	20.2	20.2
		Fuel oil B	$356	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	20.0	20.0
		Fuel oil C for general use	$357	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	20.2	20.2
		Fuel oil C for power generation use	$358	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.8	19.8
	Miscellaneous oil products	Lubricant oil	$365	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.9	19.9
		Other heavy oil products	$370	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.4	20.4
		Petroleum coke	$375	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	24.5	24.5
		Galvanic furnace gas	$376	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	41.7	41.7
		Refinery gas	$380	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.4	14.4
		Liquefied petroleum gas (LPG)	$390	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.4	16.4
Natural Gas	Liquefied natural gas (LNG)		$410	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.7	14.0
	Indigenous natural gas		$420	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	14.0	14.0
	Indigenous natural gas		$421	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	14.0	14.0
	Coal mining gas		$422	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
	Boil off gas from crude oil		$423	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	14.0	14.0
Town Gas	Town gas		$460	14.3	14.3	14.1	14.0	14.0	13.9	14.0	13.9	14.1	14.1	14.0	14.1	14.1
	Small scale community gas		$470	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.5	16.4	16.4
(Reference) biomass	Biomass power generation		$N131	30.2	30.2	30.2	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	29.6	29.6
	Solid biomass		$N133	30.2	30.2	30.2	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	29.6	29.6
	Liquid biomass		$N134	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.2	17.6	17.6
	Gas biomass		$N135	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	13.5	13.5
	Thermal use of black liquor		$N136	26.8	26.8	26.8	25.6	25.6	25.6	25.6	25.6	25.6	25.6	25.6	24.9	24.9
	Thermal use of waste woods		$N137	30.2	30.2	30.2	30.9	30.9	30.9	30.9	30.9	30.9	30.9	30.9	29.6	29.6

1) Code number for fuels of the *General Energy Statistics* (Energy Balance Table)

Table 3-11 References of carbon emission factors for fuel combustion

Fuel			Code [1]	References (1990-2012)	References (2013-)
Coal	Steel making coal		$110	-	-
	Coking coal		$111	2006 IPCC Guidelines	Actual measurements provided by JISF
	Pulverized coal injection (PCI) coal		$112	Same as coking coal	Actual measurements provided by JISF
	Imported steam coal		$130	Same as imported steam coal for general use	Same as imported steam coal for general use
	Imported steam coal for general use		$131	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by FEPC
	Imported steam coal for power generation use		$132	Same as imported steam coal for general use	Same as imported steam coal for general use
	Indigenous produced steam coal		$135	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by FEPC
	Hard coal, anthracite & lignite		$140	2006 IPCC Guidelines	Estimated by interpolating by approximate equation of imported steam coal
Coal Products	Coke		$161	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by JISF
	Coal tar		$162	2006 IPCC Guidelines	2006 IPCC Guidelines
	Coal briquette		$163	Report on Estimation of CO_2 Emissions in Japan	Values of hard coal, anthracite & lignite
	Coke oven gas		$171	2006 IPCC Guidelines	Actual measurements provided by JISF
	Blast furnace gas		$172	Values based on the carbon balance in blast furnace and converter furnace	Values based on the carbon balance in blast furnace and converter furnace
	Converter furnace gas		$175	Kainou (2005)	Actual measurements provided by JISF
Oil	Crude oil for refinery use		$210	Same as crude oil for refinery use	Same as crude oil for refinery use
	Crude oil for refinery use		$211	Values calculated by weighted average of emission factors by brands based on import share	Values calculated by weighted average of emission factors by brands based on import share
	Residual and straight run fuel oil for refinery use		$214		
	Crude oil for power generation use		$220	Estimated by interpolating by approximate equation of crude oil for refinery use	Estimated by interpolating by approximate equation of crude oil for refinery use
	Bituminous mixture fuel		$221	2006 IPCC Guidelines	2006 IPCC Guidelines
	Natural gas liquid (NGL) / condensate		$230	Values calculated by weighted average of emission factors by brands based on import share	Values calculated by weighted average of emission factors by brands based on import share
	NGL/condensate for refinery use		$231		
	NGL/condensate for power generation use		$232		
	NGL/condensate for petrochemical use		$233		
Oil Products		Pure naphtha	$281	Report on Estimation of CO_2 Emissions in Japan	Values of regular gasoline
		Reformed feedstock Oil	$282	Values of gasoline	Values of premium gasoline
	Fuel oil	Gasoline	$310	Report on Estimation of CO_2 Emissions in Japan	Values calculated by weighted average of regular gasoline and premium gasoline based on the share of indigenous production by type
		Jet fuel oil	$320	Report on Estimation of CO_2 Emissions in Japan	Values calculated by weighted average of kerosene type jet fuel and gasoline type jet fuel based on the share of domestic consumption by type
		Kerosene	$330	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by PAJ
		Gas oil or diesel oil	$340	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by PAJ
		Fuel oil A	$351	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by PAJ
		Fuel oil C	$355	Same as fuel oil C for general use	Same as fuel oil C for general use
		Fuel oil B	$356	Report on Estimation of CO_2 Emissions in Japan	Estimated by interpolating by approximate equation of oil products
		Fuel oil C for general use	$357	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by PAJ
		Fuel oil C for power generation use	$358	Report on Estimation of CO_2 Emissions in Japan	Estimated by interpolating by approximate equation of oil products
	Miscellaneous oil products	Lubricant oil	$365	Report on Estimation of CO_2 Emissions in Japan	Estimated by interpolating by approximate equation of oil products
		Other heavy oil products	$370	Report on Estimation of CO_2 Emissions in Japan	Estimated by interpolating by approximate equation of oil products
		Petroleum coke	$375	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by JCIA
		Galvanic furnace gas	$376	Values of converter furnace gas	Values of converter furnace gas
		Refinery gas	$380	Report on Estimation of CO_2 Emissions in Japan	Actual measurements provided by PAJ
		Liquefied petroleum gas (LPG)	$390	Values calculated by weighted average of theoretical EF of propane and butane based on the share of these matters in indigenous production and imports of the fuel	Values calculated by weighted average of theoretical EF of propane and butane based on the share of these matters in indigenous production and imports of the fuel
Natural Gas	Liquefied natural gas (LNG)		$410	Values calculated by weighted average of emission factors by production area based on the share of imports by country	Values calculated by weighted average of emission factors by production area based on the share of imports by country
	Indigenous natural gas		$420	2006 IPCC Guidelines	Actual measurements provided by JNGA
	Indigenous natural gas		$421	Values of indigenous natural gas	Values of indigenous natural gas
	Coal mining gas		$422	Report on Estimation of CO_2 Emissions in Japan	Values of water-dissolved non-associated gas provided by JNGA
	Boil off gas from crude oil		$423	Values of indigenous natural gas	Values of indigenous natural gas
Town Gas	Town gas		$460	Values based on the carbon balance in Town gas conversion and production	Values based on the carbon balance in Town gas conversion and production
	Small scale community gas		$470	Values of liquefied petroleum gas	Values of liquefied petroleum gas
(Reference) Biomass	Biomass power generation		$N131	Values of thermal use of waste woods	Values of thermal use of waste woods
	Solid biomass		$N133	Values of thermal use of waste woods	Values of thermal use of waste woods
	Liquid biomass		$N134	Theoretical carbon emission factor of ethanol in normal condition	Theoretical carbon emission factor of ethanol in SATP condition
	Gas biomass		$N135	Theoretical carbon emission factor of methane in normal condition	Theoretical carbon emission factor of methane in SATP condition
	Thermal use of black liquor		$N136	Actual measurements provided by JPA	Actual measurements provided by JPA
	Thermal use of waste woods		$N137	Actual measurements provided by JPA	Actual measurements provided by JPA

1) Code number for fuels of the *General Energy Statistics* (Energy Balance Table)

2) JISF: Japan Iron and Steel Federation, FEPC: Federation of Electric Power Companies of Japan, PAJ: Petroleum Association of Japan, JCIA: Japan Chemical Industry Association, JNGA: Japan Natural Gas Association, JPA: Japan Paper Association, SATP: Standard ambient temperature and pressure

(a) Energy sources other than Blast Furnace Gas (BFG) and Town gas

The values used for carbon emission factors of energy sources other than blast furnace gas (BFG) and town gas were provided in "*The Report on Estimation of CO_2 Emissions in Japan* (Environmental Agency, 1992)", "*GHGs Estimation Methods Committee Report* (Committee for the Greenhouse Gases Emissions Estimation Methods, Ministry of the Environment)", "*Recommendation of the Draft Revised Standard Calorific Value and Carbon Emission Factor for Fossil Fuel Energy Sources in Japan*" (Kainou, 2014) and "*2006 IPCC Guidelines*".

- ***Methodological issues of carbon emission factors from FY1990 to FY2012***

The evaluation results in *Evaluating and Analyzing the Validity of Carbon Emission Factors for Different Fuels* (Kainou, 2005) were adopted for setting emission factors. In the choice of carbon emission factors, an adequacy assessment of emission factors was conducted in *the Report on Estimation of CO_2 Emissions in Japan* (Environmental Agency, 1992), which were used in the inventories submitted up to 2005. These were assessed based on the following three criteria. The values assessed as adequate continue to be used in this inventory.

1) Evaluation and analysis by comparison of theoretical upper and lower limits
2) Evaluation and analysis by comparison with the *Revised 1996 IPCC Guidelines* default values
3) Group evaluation and analysis by carbon balance using the *General Energy Statistics*

The summaries of evaluations are indicated below.

1) Evaluation and analysis by comparison of theoretical upper and lower limits

The validity of carbon emission factors is evaluated by comparing the intended emission factor and the emission factor calculated theoretically from standard enthalpy change of the formation of pure matter, such as hydrogen, methane and carbon monoxide, because most of the fuels for which carbon emission factors are required to be evaluated are hydrocarbons containing a few impurities, and because a physicochemical correspondence exists between the standard gross calorific values of pure hydrocarbons and carbon emission factors.

2) Evaluation and analysis by comparison with the *Revised 1996 IPCC Guidelines* default values

The validity of carbon emission factors is judged by using the *Revised 1996 IPCC Guidelines* default values or the *2006 IPCC Guidelines* reference values[6] and their statistical reliability (uncertainty) information. However, because the average properties of fuels envisaged in the IPCC Guidelines and those of the fuels used in Japan are not necessarily the same, carbon emission factors can be appropriately judged based on the statistical examination of the group evaluation and analysis mentioned below even when figures deviate, as long as a valid reason for the deviation exists.

3) Group evaluation and analysis by carbon balance using the *General Energy Statistics*

The validity of fuel-specific carbon emission factors for some petroleum and coal product factor groups can be evaluated using the *General Energy Statistics* to analyze the carbon balance in coal and oil products.

[6] When *Evaluating and Analyzing the Validity of Carbon Emission Factors for Different Fuels* was submitted, the *2006 IPCC Guidelines* had not been published yet. These values were reference values, and some of these reference values were revised.

- ***Methodological issues of carbon emission factors from FY2013 onward***

The values through the survey conducted by the Ministry of Economy Trade and Industry (METI) and the Ministry of the Environment (MOE) on the standard calorific values (CV) and carbon emission factors (CEF) in FY2013 and FY2014 were adopted. The outline is described below.

1) Outline of the Survey

The METI and MOE collected the data such as physical properties of various energy sources that relevant industrial associations had, and conducted the survey on the actual measurements of physical properties of samples provided by relevant industrial associations in FY2013 and FY2014. The standard CVs and CEFs from FY2013 were presented in "*Recommendation of the Draft Revised Standard Calorific Value and Carbon Emission Factor for Fossil Fuel Energy Sources in Japan*" (Kainou, 2014) based on the physical properties of various energy sources obtained from the survey.

2) Basic Methodology of Estimation of Carbon Emission Factors

The standard CVs and CEFs by energy source were established, based on the properties and priority in accuracy of various energy sources, by the following methods: (1) estimation from theoretical values; (2) estimation from the actual measurements provided by the relevant industrial associations and the actual measurements by the METI and MOE; (3) estimation from the values of major energy sources, and from the weighted average and/or regression analysis using those values; (4) continuous use of the current values .

The estimation methods of the standard CVs and CEFs of solid, liquid and gaseous fuels based on the theoretical values and the actual measurements (corresponding to the methods (1) and (2)) are as follows:

Gaseous fuels

In the cases where component composition can be measured by such techniques as gas chromatography in some energy sources like gaseous fuels, standard CVs and CEFs are derived by weighted average of those of pure matters by composition. Theoretical CVs and CEFs of pure matters such as methane and propane are estimated from physical properties like standard enthalpy change of the formation.

Solid and liquid fuels

In the cases where energy sources are solid fuels or liquid fuels that the weighted average by pure matters are not feasible, standard CVs and carbon contents are estimated by statistical treatment of the actual measurements of physical properties such as gross calorific values and carbon contents.

The method (3) is that the standard CVs and CEFs of subject energy sources are estimated by interpolating by the approximate equations. The equations were established based on the actual measurements of steam coal, crude oil and oil products, and they can estimate CVs and CEFs from the physical properties such as density and water content.

3) Quality Control

The CVs and CEFs estimated above were compared with the current values and the default values of the *2006 IPCC Guidelines*, and then the validity is confirmed.

(b) Blast Furnace Gas (BFG)

During the iron and steel production process, in the blast furnace and converter furnace, the amount of energy and carbon contained in coke and Pulverized Coal Injection (PCI) coal which are injected to the processes and those contained in BFG and Converter Furnace Gas (CFG, or Linz-Donawitz converter gas (LDG)) which are calculated should be theoretically balanced. Since the composition of BFG is unstable, the emission factors for BFG were established with annually calculated values in order to keep the carbon balance in the blast furnace and converter furnace during the iron and steel production process.

The amount of carbon (excluding the carbon contained in CFG from the carbon contained in 'Coke' and 'PCI coal') injected to the blast furnace indicated under 'Steel process gas' is considered to be carbon contained in BFG. The emission factor for BFG was established as the carbon described above divided by the calorific value of the BFG generated. The equation for the emission factor, the overview of the carbon flow for iron and steel and the calculation process are shown below.

The calculation to establish the emission factor for BFG is conducted every year.

$$EF_{BFG} = \left[\left(A_{coal} \times EF_{coal} + A_{coke} \times EF_{coke}\right) - A_{CFG} \times EF_{CFG}\right] / A_{BFG}$$

EF : Carbon emission factor [t-C/TJ]
A : Fuel consumption [TJ]
BFG : Blast Furnace Gas
coal : PCI coal
coke : Coke
CFG : Converter Furnace Gas

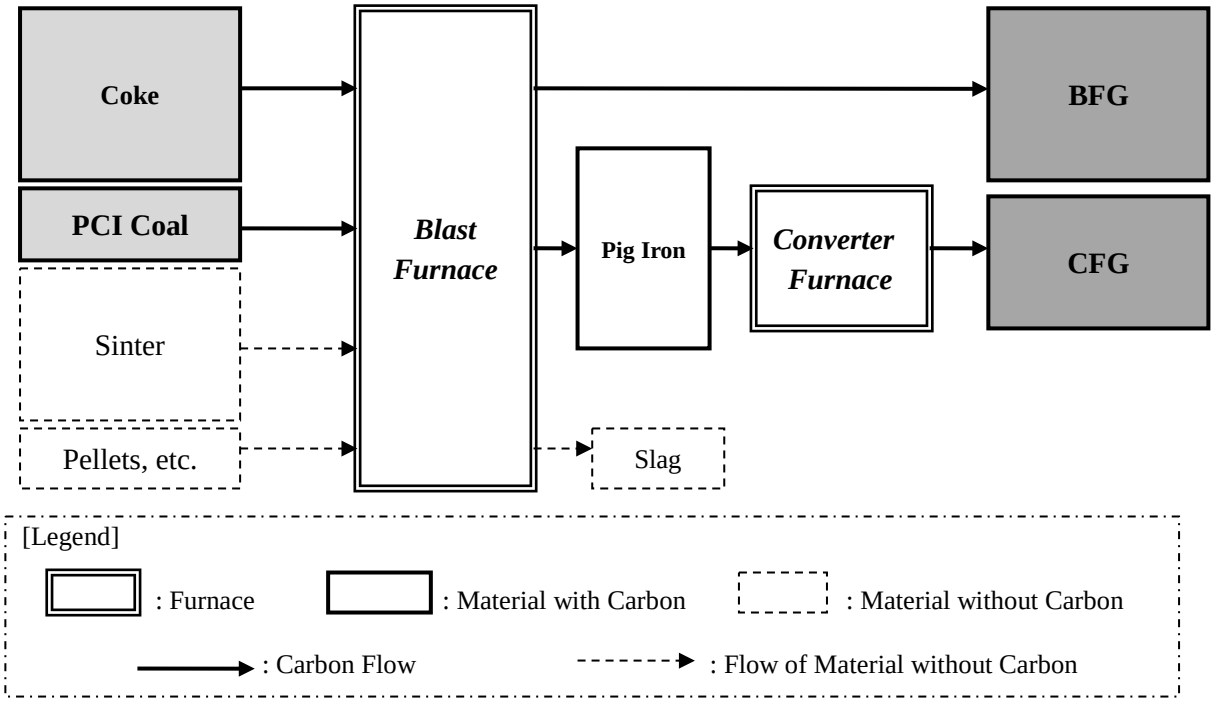


Figure 3-4 Overview of carbon flow for iron & steel manufacturing

Table 3-12 Calculation process of emission factors for BFG

Steel process gas		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Note
Input															
PCI coal	kt-C	1,650	2,619	3,351	3,014	3,126	3,408	2,859	2,576	3,444	3,669	4,019	4,592	4,283	A
Coke	kt-C	12,739	11,400	12,221	11,497	11,746	11,910	10,928	10,458	11,194	10,137	10,187	11,341	10,917	B
Input total	kt-C	14,389	14,019	15,572	14,511	14,872	15,318	13,786	13,034	14,637	13,806	14,206	15,933	15,200	C: A + B
Output															
CFG (LDG)	kt-C	2,541	2,359	2,726	2,804	2,999	3,038	2,727	2,589	2,798	2,502	2,612	2,930	2,941	D
Difference	kt-C	11,848	11,660	12,846	11,707	11,874	12,280	11,059	10,444	11,839	11,304	11,594	13,002	12,260	E: C - D
Output															
BFG	TJ	434,801	433,504	481,768	441,357	449,335	465,388	417,636	393,685	448,708	429,625	442,758	488,319	461,735	F

EF BFG	t-C/TJ	27.2	26.9	26.7	26.5	26.4	26.4	26.5	26.5	26.4	26.3	26.2	26.6	26.6	E / F

(c) Town gas

"Town gas" consists of "general gas" provided by general gas supplier and "small-scale community gas" provided by small-scale community gas supplier.

Small-scale community gas suppliers:

Because most of the small-scale community gas is LPG, the same emission factor was adopted as for LPG.

General gas suppliers:

Town gas (general gas) is produced from a mixture of raw materials and air dilution. In order to calculate the town gas emission factors, the total carbon contained in fossil fuel used as raw materials was divided by the total calorific value of the produced town gas. The emission factors for town gas were established based on the carbon balance in "town gas production". To calculate the town gas emission factors, the total carbon in fossil fuel inputs used as raw materials (COG, Kerosene, Refinery gas, LPG, LNG and Indigenous natural gas) was divided by the total calorific value of the town gas production.

The calculation to establish the emission factor for town gas is conducted every year.

$$EF_{TG} = \sum_i \left(A_i \times EF_i \right) / P_{TG}$$

EF : Carbon emission factor [t-C/TJ]
A : Fuel consumption [TJ]
P : Calorific value of the town gas production [TJ]
TG : Town gas
i : Feedstocks (COG, Kerosene, Refinery gas, LPG, LNG, Indigenous natural gas)

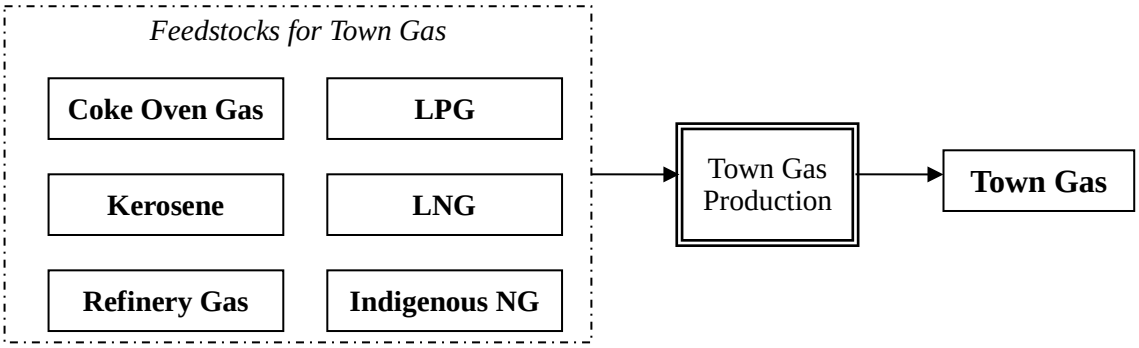


Figure 3-5 Manufacturing flow for town gas

Table 3-13 Calculation process of emission factors for town gas

Town gas production		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Note
Input															
COG	kt-C	211	134	105	22	0	0	0	0	0	0	0	0	0	a1
Kerosene	kt-C	200	275	69	6	0	0	0	0	0	0	0	0	0	a2
Refinery gas	kt-C	186	199	186	145	101	95	88	13	0	0	0	0	0	a3
LPG	kt-C	1,957	2,129	1,809	1,092	748	743	694	716	799	870	891	930	992	a4
LNG	kt-C	6,411	9,342	11,944	16,987	19,085	20,289	19,880	19,667	21,446	21,947	21,926	21,218	21,860	a5
Indigenous NG	kt-C	551	661	848	1,190	1,534	1,748	1,822	1,768	1,603	1,775	1,683	1,590	1,609	a6
Input total	kt-C	9,515	12,740	14,962	19,442	21,468	22,875	22,485	22,164	23,848	24,592	24,499	23,739	24,461	A: Σ a
Output															
Town gas	TJ	664,661	892,307	1,061,122	1,391,962	1,534,754	1,644,783	1,607,991	1,593,032	1,697,063	1,745,748	1,755,849	1,686,549	1,730,426	B
EF Town gas	t-C/TJ	14.3	14.3	14.1	14.0	14.0	13.9	14.0	13.9	14.1	14.1	14.0	14.1	14.1	A/B

➢ *Oxidation factor*

For each type of energy, country-specific oxidation factors were established considering the actual conditions of fuel combustion in Japan based on survey on related industrial associations, manufacturing corporations and experts.

Gaseous Fuels

Every measurement result of soot concentration of boilers to generate power in 2004 for gaseous fuels combustion showed that no soot was emitted; therefore, it is assumed that gaseous fuels are completely combusted. The results of questionnaires also showed that gaseous fuels were completely combusted. Hence, the oxidation factor for gaseous fuel combustion was set to 1.0.

Table 3-14 Data of gaseous fuel combustion

Fired condition	Provider	Survey
Complete combustion	The Federation for Electric Power Companies Japan (FEPC)	Measurement of soot concentration of boilers to generate power in 2004

Liquid Fuels

The carbon contained in liquid fuels is considered to be almost completely combusted; however, unburned fuel loss, about 0.5%, may occur depending on its fired condition. Because data of actual measurements were not available, considering meticulous combustion management and smoke treatment in Japan, the oxidation factor for liquid fuels combustion was set to 1.0.

Solid Fuels

The oxidation factor for solid fuels varies depending on the fired condition, type of furnace, and coal property; therefore, it is quite difficult to obtain a representational data set of actual measurements of unburned fuel loss. Meanwhile, almost all the unburned carbon generated during combustion in furnace is considered to be contained in coal ash. Coal ash is effectively utilized or landfilled. Carbon contained in coal ash which is used as raw material of cement is oxidized to CO_2 and emitted into the atmosphere during the calcinations process.

The average oxidation factor from 1990 to 2003 considering unburned carbon oxidized in the firing process of coal ash was 0.996, expressed as 3 digits. Usually 2 digits are considered to be adequate in the view of other coefficients' accuracy; therefore, the oxidation factor for solid fuels was set to 1.0 rounded off to two digits.

- ***Activity Data***

The fuel consumption data given in the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy were used for the activity data. Table 3-15 shows the trend of energy consumption.

Table 3-15 Energy consumptions in Energy Industries (1.A.1) (unit: PJ)

Fuel [1)]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Liquid fuels	2,529	2,176	1,590	1,640	1,441	1,868	1,622	1,224	1,329	1,854	2,134	1,877	1,419
Solid fuels	1,076	1,477	1,869	2,506	2,426	2,625	2,544	2,452	2,589	2,453	2,591	2,866	2,807
Gaseous fuels	1,562	1,786	2,164	2,044	2,272	2,525	2,481	2,482	2,603	3,251	3,467	3,467	3,501
Other fossil fuels	196	219	258	283	279	275	264	246	245	242	259	245	238
Biomass	0.2	0.7	0.8	27	26	28	27	24	71	80	91	94	93
Total	5,363	5,658	5,881	6,501	6,444	7,320	6,937	6,428	6,837	7,881	8,541	8,549	8,058

1) Fuel type of Common Reporting Format (CRF)

The *General Energy Statistics* (Energy Balance Table) provides a comprehensive overview of domestic energy supply and demand to grasp what are converted from energy sources, such as coal, oil, natural gas and others, provided in Japan, and what are consumed in what sectors. The objective of this *General Energy Statistics* is to help to quantitatively understand energy supply and demand and to make judgments about the situation, in addition to helping with planning for energy and environmental policy, and with measuring, assessing, and otherwise gauging policy effectiveness.

The *General Energy Statistics* shows the main energy sources used in Japan as “Columns” and the supply, conversion and consumption sectors as “Rows” in a matrix. Specifically, the columns comprise 11 major categories (coal, coal products, oil, oil products, natural gas, town gas, renewable and recovered energy, large-scale hydraulic power generation, nuclear power, electricity, and heat) and the necessary sub-categories and a more detailed breakdown of the sub-categories. The rows comprise 3 major sectors — primary energy supply (primary supply), energy transformation & own use (conversion), and final energy consumption (final consumption) — plus the necessary sub-categories and a more detailed breakdown of the sub-categories.

In calculating the energy supply and demand amounts for the *General Energy Statistics*, it is assumed that each energy source, such as gasoline or electricity, is homogeneous in terms of gross calorific value per original unit (MJ/kg, MJ/l, MJ/m^3), and that homogeneous energy sources are supplied, converted and consumed. The values for supply, conversion and consumption in original units as determined from official statistical sources are multiplied by the gross calorific value per original unit to obtain energy supply and demand amounts.

The calculation process in the *General Energy Statistics* is as follows:

(1) Setting calorific values and carbon emission factors.

(2) Building an energy supply and demand module.

(3) Preparing original unit tables (preparing a detailed table, a main table and a summary table through the module from relevant official statistics) (units in t, kl, m^3, etc.).

(4) Preparing energy unit tables (unit in J).

(5) Preparing energy-derived carbon tables (carbon content).

The *General Energy Statistics* adopts “actual calorific values” calculated based on annual official

statistics for some fuel types which can be recalculated. For other fuel types which cannot be recalculated and whose composition is stable, “standard calorific values” based on latest measurement data available at the time, relevant official statistics and documents are adopted.

The complete Energy Balance Tables for the years since FY1990 are available on the following internet site:

http://www.enecho.meti.go.jp/statistics/total_energy/results.html#headline2 (Japanese version only)

Please refer to the simplified energy balance tables provided in Annex 4 (A4.2).

For the activity data for energy industries, the data reported in the following sectors in the *General Energy Statistics* were used: “manufacture of coal products” [#210000]; “oil products” [#220000]; “gas conversion and production” [#230000]; "power generation” [#240000] which reports energy consumption associated with electric power generation by electric power suppliers; “district heat supply” [#270000] which provides energy consumption associated with heat energy and cold energy by thermal energy suppliers; “own use, coal products” [#301100] which reports energy consumption associated with captive (own) use of energy industries; “own use, oil products” [#301200]; “own use, gas conversion and production ” [#301300]; “own use, power generation” [#301400]; “own use, district heat supply” [#301500].

Table 3-16 shows the correspondence between the sectors of Japan’s Energy Balance Table from the *General Energy Statistics* and those of the CRF.

Table 3-16 Correspondence between sectors of Japan’s Energy Balance Table and those of the CRF (1.A.1)

CRF		General Energy Statistics	
1A1	Energy industries		
1A1a	Public electricity and heat production	Power generation	#240000
		Own use; Power generation	#301400
		District heat supply	#270000
		Own use; District heat supply	#301500
1A1b	Petroleum refining	Oil products	#220000
		Own use; Oil products	#301200
		Auto power generation; Manufacture of petroleum products	#253171
		Auto steam generation, Manufacture of petroleum products	#263171
		Final energy consumption, Manufacture of petroleum products	#626510
		Non-energy and feedstock use; Manufacture of petroleum products	#951540
1A1c	Manufacture of solid fuels and other energy industries	Manufacture of coal products	#210000
		Own use; Coal products	#301100
		Auto power generation; Manufacture of coal products and miscellaneous	#253175
		Auto steam generation, Manufacture of coal products and miscellaneous	#263175
		Final energy consumption; Manufacture of coal products and miscellaneous	#626550
		Gas conversion and production	#230000
		Own use; Gas conversion and production	#301300

#95xxxx items are subtracted as non-energy use activities.

- *Gross calorific value*

The gross calorific values used in *General Energy Statistics* are adopted. Table 3-17 shows the trends in gross calorific value for each fuel type. *General Energy Statistics* adopts actual calorific values calculated based on annual official statistics for some fuel types which can be recalculated. For other fuel types which cannot be recalculated and whose composition is stable, “standard calorific values” based on latest measurement data available at the time, relevant official statistics and documents are

adopted. The "standard calorific values" are revised approximately once in every 5 years. The latest revision was conducted to the FY2013 values with the revision of the carbon emission factors.

The gross calorific value (GCV) trends for solid fuels are declining since 1990. From 1970 to 1990, Japanese steel manufacturers used conventional coking coal for feedstock for coke, but due to the shortage of coking coal and the increase of price, they developed a new coke making technology to use steam coal with pre-treatment as feedstock for coke instead. Similarly, they changed PCI coal from coking coal and steam coal mixture to steam coal with pre-treatment. The Japanese steel manufacturers have been trying to make high-quality coke from cheap coal for economic reasons. Because conventional coking coal has a higher carbon content and GCV than steam coal, and because the new technology was introduced gradually, the apparent GCV gradually decreased in these years.

Table 3-17 Trends in gross calorific value of each fuel type

Fuel			Code	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Coal	Steel making coal		$110	MJ/kg	31.8	30.5	29.0	29.0	29.0	29.0	29.0	29.0	28.9	28.9	28.9	28.7	28.7
	Coking coal		$111	MJ/kg	31.8	30.5	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	28.9	28.9
	Pulverized coal injection (PCI) coal		$112	MJ/kg	31.8	30.5	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.0	28.0
	Imported steam coal		$130	MJ/kg	26.0	26.0	26.6	25.7	25.7	25.7	25.7	25.7	25.7	25.7	25.7	26.0	26.0
	Imported steam coal for general use		$131	MJ/kg	26.0	26.0	26.6	25.7	25.7	25.7	25.7	25.7	25.7	25.7	25.7	26.0	26.0
	Imported steam coal for power generation use		$132	MJ/kg	24.9	26.1	26.4	25.5	25.6	25.5	25.3	25.4	25.3	25.3	25.3	26.0	26.0
	Indigenous produced steam coal		$135	MJ/kg	24.3	24.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	25.3	25.3
	Hard coal, anthracite & lignite		$140	MJ/kg	27.2	27.2	27.2	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	27.8	27.8
Coal Products	Coke		$161	MJ/kg	30.1	30.1	30.1	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.2	29.2
	Coal tar		$162	MJ/kg	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3	37.3
	Coal briquette		$163	MJ/kg	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9
	Coke oven gas		$171	MJ/m^3	21.5	21.6	21.3	21.4	21.4	21.3	21.2	21.1	21.3	21.1	20.7	19.1	19.1
	Blast furnace gas		$172	MJ/m^3	3.5	3.6	3.6	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.3	3.3
	Converter furnace gas		$175	MJ/m^3	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	7.6	7.6
Oil	Crude oil for refinery use		$210	MJ/l	38.3	38.3	38.2	38.1	38.1	38.1	38.2	38.1	38.2	38.2	38.1	38.2	38.0
	Crude oil for refinery use		$211	MJ/l	38.3	38.3	38.2	38.1	38.1	38.1	38.2	38.1	38.2	38.2	38.1	38.2	38.0
	Residual and straight run fuel oil for refinery use		$214	MJ/l	38.3	38.3	38.2	38.1	38.1	38.1	38.2	38.1	38.2	38.2	38.1	41.2	40.5
	Crude oil for power generation use		$220	MJ/l	39.1	39.2	39.6	38.5	39.3	39.5	39.5	39.7	39.7	39.4	39.3	39.3	39.3
	Bituminous mixture fuel		$221	MJ/kg	30.1	30.3	29.9	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4	22.4
	Natural gas liquid (NGL) & condensate		$230	MJ/l	35.7	35.5	35.4	35.0	35.0	35.5	32.9	34.8	34.8	36.9	34.8	34.8	34.4
	NGL&condensate for refinery use		$231	MJ/l	35.7	35.5	35.4	35.0	35.0	35.5	32.9	34.8	34.8	36.9	34.8	34.8	34.4
	NGL&condensate for power generation use		$232	MJ/l	35.7	35.5	35.4	35.0	35.0	35.5	32.9	34.8	34.8	36.9	34.8	34.2	34.2
	NGL&condensate for petrochemical use		$233	MJ/l	35.7	35.5	35.4	35.0	35.0	35.5	32.9	34.8	34.8	36.9	34.8	34.6	34.2
Oil Products		Pure naphtha	$281	MJ/l	33.6	33.6	33.6	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.3	33.3
		Reformed feedstock Oil	$282	MJ/l	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	33.7	33.7
	Fuel oil	Gasoline	$310	MJ/l	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	33.4	33.4
		Jet fuel oil	$320	MJ/l	36.4	36.4	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.3	36.3
		Kerosene	$330	MJ/l	36.8	36.8	36.8	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.5	36.5
		Gas oil or diesel oil	$340	MJ/l	38.1	38.1	38.2	37.8	37.9	38.0	37.9	37.9	38.1	38.0	37.9	38.0	38.0
		Fuel oil A	$351	MJ/l	39.7	39.6	39.3	39.1	40.0	40.0	39.9	39.9	39.9	39.8	39.8	38.9	38.9
		Fuel oil C	$355	MJ/l	40.2	40.3	40.3	40.3	40.4	40.2	40.3	40.4	40.4	40.0	39.7	40.9	41.1
		Fuel oil B	$356	MJ/l	40.2	40.2	40.4	40.4	40.4	40.4	40.4	40.4	40.4	40.4	40.4	40.4	40.4
		Fuel oil C for general use	$357	MJ/l	40.2	40.3	40.3	40.3	40.4	40.2	40.3	40.4	40.4	40.0	39.7	40.9	41.1
		Fuel oil C for power generation use	$358	MJ/l	41.1	41.1	41.3	41.2	41.2	41.2	41.2	41.2	41.3	41.2	41.2	41.2	41.2
	Miscellaneous oil products	Lubricant oil	$365	MJ/l	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2
		Other heavy oil products	$370	MJ/kg	39.2	39.3	39.4	39.4	39.4	39.3	39.3	39.5	39.4	39.0	38.7	40.0	40.1
		Oil coke	$375	MJ/kg	35.6	35.6	35.6	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	33.3	33.3
		Galvanic furnace gas	$376	MJ/m^3	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	7.6	7.6
		Refinery gas	$380	MJ/m^3	39.3	39.3	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	44.9	46.7	46.7
		Liquefied petroleum gas (LPG)	$390	MJ/kg	50.5	50.6	50.7	50.7	50.7	50.7	50.7	50.7	50.8	50.8	50.8	50.1	50.1
Natural Gas	Liquefied natural gas (LNG)		$410	MJ/kg	54.6	54.6	54.6	54.6	54.5	54.5	54.6	54.6	54.6	54.7	54.7	55.0	54.5
	Indigenous natural gas		$420	MJ/m^3	42.1	42.4	42.6	42.9	43.6	44.6	44.7	44.8	44.7	44.7	44.8	40.1	40.1
	Indigenous natural gas		$421	MJ/m^3	42.1	42.4	42.6	42.9	43.6	44.6	44.7	44.8	44.7	44.7	44.8	40.1	40.1
	Coal mining gas		$422	MJ/m^3	36.0	36.0	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	15.3	15.3
	Boil off gas from crude oil		$423	MJ/m^3	42.1	42.4	42.6	42.9	43.6	44.6	44.7	44.8	44.7	44.7	44.8	40.1	40.1
Town Gas	Town gas		$460	MJ/m^3	41.9	41.9	41.1	44.8	44.8	44.8	44.8	44.8	44.8	44.8	44.8	40.3	42.5
	Small scale community gas		$470	MJ/m^3	105.4	103.6	102.3	101.5	101.6	101.9	101.9	102.0	101.1	101.2	101.0	98.8	98.3
Biomass	Biomass power generation		$N131	MJ/kWh	9.3	9.3	8.9	8.7	8.7	8.7	8.7	8.6	8.6	8.6	8.6	8.6	8.4
	Solid biomass		$N133	MJ/kg	15.4	15.4	15.4	19.9	19.8	17.7	18.5	18.6	17.4	17.7	17.9	17.6	17.6
	Liquid biomass		$N134	MJ/l	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.9	23.4	23.4
	Gas biomass		$N135	MJ/m^3	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	21.4	21.4
	Thermal use of black liquor		$N136	MJ/kg	12.6	12.6	12.6	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.2	13.6	13.6
	Thermal use of waste woods		$N137	MJ/kg	16.7	16.7	16.7	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	17.1	17.1

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties of emission factors are set by the upper and lower limits of 95% confidence intervals derived from the actual measurements of carbon emission factors. The upper and lower limits of uncertainties of activity data are set by the standard deviations of the statistical discrepancies [#400000] divided by domestic primary energy supply [#190000] from 1990 to 2013 for solid, liquid and gaseous fuels respectively, taking account of difficulty to set the uncertainties of energy consumption by each fuel and sector from the *General Energy Statistics*, or the source of activity data. As a result, the uncertainty was determined to be -2% to +1% for CO_2 emissions from combustion of solid, liquid and gaseous fuels. See section 7.4.3 for the uncertainty of CO_2 emissions from waste incineration for energy purposes and with energy recovery.

- ***Time-series Consistency***

The emissions were calculated in a consistent manner in all time-series.

The carbon emission factors of all energy sources have been calculated by a consistent estimation method in all time-series.

The activity data was used from data in the *General Energy Statistics* in all time-series, and the statistics were made by a consistent estimation method in all time-series.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The CO_2 emissions in FY2006, FY2012 and FY2013 were recalculated with a revision of the carbon emission factors and the fuel consumption of *General Energy Statistics*.

Updating the statistical data and improving the estimation methodology in the waste sector, CO_2 emissions in FY2001 and FY2004-FY2013 were recalculated. See section 7.4.3 for details.

See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.5. CH_4 and N_2O Emissions from Energy Industries (1.A.1.:CH_4, N_2O)

a) Category Description

This source category provides the methods for estimating CH_4 and N_2O emissions from public electricity and heat production (1.A.1.a), petroleum refining (1.A.1.b), and manufacture of solid fuels and other energy industries (1.A.1.c).

CH_4 is generated as a result of incomplete combustion, and as such, if sufficient care is taken to ensure complete combustion, CH_4 will not be generated. N_2O is generated through the reaction of NO,

which is generated by combustion, with nitrogen-containing volatile components in fuels. Consequently, the higher the nitrogen content of the fuel used, the more likely it is that N_2O will be generated. However, the reaction that produces N_2O is also dependent on temperature, with N_2O more likely to be generated at lower temperatures. More N_2O will accordingly be generated by furnaces such as fluidized bed boilers that burn fuel at low temperatures (800–900°C). N_2O can also be generated when NO_X makes contact with catalysts for NO_X removal.

The contribution of CH_4 and N_2O emissions from this category relative to total GHG emissions is small in Japan. The N_2O emissions from fluidized bed boilers are relatively large in this category. The N_2O emissions from fluidized bed boilers contribute to the increase of GHG emissions from this category, since fluidized bed boilers have been introduced in Japan from 1990.

The N_2O emissions from solid fuel in 1.A.1.a (Public electricity and heat production) increased between FY1994 and FY1995. The reason for the increase was that a new large sized fluidized-bed boiler for power generation was introduced in FY1995. As a result, the solid fuel consumption of fluidized-bed boilers for public power generation increased in FY1995, resulting in an increase of N_2O emissions from solid fuels in this category.

CH_4 emitted in coke production is reported in this category. We have no measurements of the concentration of N_2O in the gas leaking from coking furnace lids, but we decided that N_2O emissions from this source are not applicable the reason being that experts say that N_2O is likely not produced because the atmosphere in a coke oven is normally at least 1,000°C, and is reducing.

b) Methodological Issues

- ***Estimation Method***

➢ *Furnaces*

Because it is possible to use fuel-specific, sector-specific and furnace-specific activity data, and also to set country-specific emission factors by furnace, CH_4 and N_2O emissions from fuel combustion in this category are calculated by using Tier 3 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol.2, Page 1.9, Fig. 1.2).

The estimation equation is as follows. The emissions were calculated by multiplying fuel-specific, furnace-specific and sector-specific activity data by fuel-specific and furnace-specific emission factors.

$$E = \sum_{ij} \left(EF_{ij} \times A_{ijk} \right)$$

E	: Emissions from combustion of fuel by stationary sources [kg-CH_4, kg-N_2O]
EF_{ij}	: Emission factor for fuel type i, furnace type j [kg-CH_4/TJ, kg-N_2O/TJ]
A_{ijk}	: Fuel consumption for fuel type i, furnace type j, sector k [TJ]
i	: Fuel type
j	: Furnace type
k	: Sector

➢ *Coke Production*

CH_4 emissions from coke production were calculated by multiplying coke production amount by

Japan's country-specific emission factor, based on the method given in the *2006 IPCC Guidelines*.

➢ *Incineration of waste for energy purposes and with energy recovery*

See section 7.4.3

● ***Emission Factors***

➢ *Furnaces*

Chimney flue CH_4, N_2O and O_2 concentrations, theoretical (dry) exhaust gas volumes, theoretical air volumes, and higher heating values (gross calorific values) shown in Table 3-18 were employed based on data obtained from surveys conducted in Japan (Table 3-19) to establish emission factors for each kind of facility using the following combustion calculation formula. The emission factor of biofuels without black liquor were used after conversion to the gross calorific value from the default value of the *2006 IPCC Guidelines* (Vol.2, page 2.16-2.23, table 2.2-2.5)

$$EF = C_{CH_4,N_2O} \times \{G_0' + (m-1) \times A_0\} \times MW / V_m / GCV$$

EF	:	Emission factor [kg-CH_4/TJ, kg-N_2O/TJ]
$C_{CH4\ or\ N2O}$	:	CH_4 or N_2O concentration in exhaust gas [ppm]
G_0'	:	Theoretical exhaust gas volume for each fuel combustion (dry) [m^3N/ original unit]
A_0	:	Theoretical air volume for each fuel combustion [m^3N/ original unit]
m	:	Air ratio = actual air volume/ theoretical air volume (-)
MW	:	Molecular weight of CH_4(constant)=16 [g/mol] Molecular weight of N_2O(constant)=44 [g/mol]
V_m	:	One mole ideal gas volume in standardized condition (constant)=22.4 [$10^{-3}m^3$/mol]
GCV	:	Gross calorific value for each fuel combustion [MJ/ original unit]

However, the air ratio "*m*" is approximately provided with O_2 concentration in exhaust gas, as shown in the equation below.

$$m = \frac{21}{21 - C_{O_2}}$$

C_{O_2} : O_2 concentration in exhaust gas (%)

CH_4 and N_2O emission factors by each fuel and furnace types were averaged after dividing the emission factor of each kind of facilities according to fuel and furnace types (Table 3-20, Table 3-21). Anomalous values were excluded according to t-testing or expert judgment when calculating the average values. Please refer to the *GHGs Estimation Methods Committee Report Part 1* (Ministry of the Environment, Committee for the Greenhouse Gases Emissions Estimation Methods, August 2006) for the actual measurement data to establish the emission factors.

- ***Emission Factors with Air-Intake Adjustment***

In Japan, until the GHG inventory was submitted in 2005, based on the results of past discussions (e.g., Japan Society for Atmospheric Environment, *Report on Emission Factor Results for Combustion Facilities*, 1997) relating to methodologies for calculating emissions, the non-CO_2 emission factors

from stationary combustion were established after accounting for the differences between emission gas concentrations and intake gas concentrations (i.e., air-intake adjustment). With this methodology, it was possible to obtain negative emission factors for some emission sources if the measurement data showed that concentrations in emission gas were lower than those in intake gas, possibly because CH_4 and N_2O present in the intake gas had been either oxidized or decomposed through the combustion process.

However, during the in-country review that was conducted in 2003, the Expert Review Team recommended Japan to replace negative emission factors by the corresponding positive ones, because, in the interest of enabling better international comparisons, the *1996 Revised IPCC Guidelines* as well as *GPG (2000)* indicate that positive emission factors should be used for calculations of emissions based on actual emissions of CH_4 and N_2O in the flue gases, though air-intake adjustments might enable accurate determination of emissions. Thus, in the inventories submitted in 2006 and thereafter, the air-intake adjustments were not made, and emission factors were determined by using the actual measured CH_4 and N_2O concentrations in emission gases.

Table 3-18 Theoretical exhaust gas and air volumes, and higher heating values for different fuels

Fuel type	Original unit	Theoretical exhaust gas volume (dry)	Higher heating value	Theoretical air volume	Remarks
		m^3N/l, kg, m^3N	kJ/l, kg, m^3N, kWh	m^3N/l, kg, m^3N	
Fuel oil A	l	8.900	39,100	9.500	1
Fuel oil B	l	9.300	40,400	9.900	1
Fuel oil C	l	9.500	41,700	10.100	1
Diesel oil	l	8.800	38,200	9.400	1
Kerosene	l	8.400	36,700	9.100	1
Crude oil	l	8.747	38,200	9.340	1
Naphtha	l	7.550	34,100	8.400	1
Other liquid fuels	l	9.288	37,850	9.687	2
Other liquid fuels (heavy)	l	9.064	37,674	9.453	2
Other liquid fuels (light)	l	9.419	35,761	9.824	2
Steam coal	kg	7.210	26,600	7.800	1
Coke	kg	7.220	30,100	7.300	1
Harvested wood	kg	3.450	14,367	3.720	2
Charcoal	kg	7.600	30,500	7.730	3
Other solid fuels	kg	7.000	33,141	7.000	2
Town gas	m^3	9.850	46,047	10.949	2
Coke oven gas (COG)	m^3	4.500	21,100	4.800	1
Blast furnace gas (BFG)	m^3	1.460	3,410	0.626	1
Liquefied natural gas (LNG)	kg	11.766	54,500	13.093	1
Liquefied petroleum gas (LPG)	kg	11.051	50,200	12.045	1
Converter furnace gas (CFG) (Linz-Donawitz gas : LDG)	m^3	2.200	8,410	1.500	1
Refinery gas (off-gas)	m^3	11.200	44,900	12.400	1
Other gaseous fuels	m^3	4.587	28,465	4.096	2
Other gaseous fuels (petroleum)	m^3	7.889	40,307	7.045	2
Other gaseous fuels (steel)	m^3	2.812	19,097	2.511	2
Other gaseous fuels (mining)	m^3	3.396	38,177	3.032	2
Other gaseous fuels (other)	m^3	4.839	23,400	4.321	2
Pulping waste liquor	kg	3.245	13,898	3.499	2
Electricity	kWh		3,600		1

Note 1: Theoretical exhaust gas and air volumes are the standard values given in the Ministry of the Environment's General Survey of the Emissions of Air Pollutants, except for town gas, LNG, and LPG, for which values calculated from constituent data were used. For town gas, the constituents of town gas 13A were considered to be representative. Regarding higher heating value, the standard calorific values given in the General Energy Statistics were used for items marked 1, and the standard values given in General Survey of the Emissions of Air Pollutants (based on the 1992 survey) for items marked 2 in the Remarks column. The higher heating value for steam coal (imported) was used as the higher heating value of steam coal. The item marked 3 in the Remarks column was set by the 2005 Committee based on reference materials.

Table 3-19 References for measurement data used in the establishment of emission factors

	References
1	Hokkaido Prefecture, Report of GHG Emissions Intensity from Stationary Combustion, 1991
2	Hyogo Prefecture, Report of GHG Emissions Intensity from Stationary Combustion, 1991
3	Osaka Prefecture, Study of GHG Emissions Intensity from Stationary Combustion, 1991
4	Hokkaido Prefecture, Report of GHG Emissions Intensity from Stationary Combustion, 1992
5	Hyogo Prefecture, Report of GHG Emissions Intensity from Stationary Combustion, 1992
6	City of Kitakyushu, Report of GHG Emissions Intensity from Stationary Combustion, 1992
7	Hyogo Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1993
8	Hyogo Prefecture, Report of GHG Emissions Intensity from Stationary Combustion, 1994
9	Kanagawa Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1995
10	Niigata Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1995
11	Osaka Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1995
12	Hiroshima Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1995
13	Fukuoka Prefecture, Report of GHG Emission Factors from Stationary Combustion, 1995
14	City of Osaka, Study of GHG Emission Factors from Stationary Combustion, 1995
15	City of Kobe, Study of GHG Emission Factors from Stationary Combustion, 1995
16	Hokkaido Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
17	Ishikawa Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
18	Kyoto Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
19	Osaka Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
20	Hyogo Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
21	Hiroshima Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1996
22	Fukuoka Prefecture, Report of GHG Emission Factors from Stationary Combustion, 1996
23	Kyoto Prefecture, Report of GHG Emission Factors from Stationary Combustion, 1997
24	Hyogo Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1997
25	Fukuoka Prefecture, Report of GHG Emission Factors from Stationary Combustion, 1997
26	Japan Society for Atmospheric Environment, Reports on Greenhouse gas emissions estimation methodology, 1996
27	Osaka Prefecture, Study of GHG Emission Factors from Stationary Combustion, 1999
28	Hyogo Prefecture, Report of GHG Emission Factors from Stationary Combustion, 2000
29	The Institute of Applied Energy, Report for Trend of Fuel Quality in Lowering Environmental Atmospheric Quality, 2000
30	Measurement Data prepared by the Committee for the Greenhouse Gases Emissions Estimation Methods in FY1999
31	Data prepared by the Federation of Electric Power Companies of Japan
32	IPCC, 2006 IPCC Guidelines, 2006

Table 3-20 CH_4 emission factors for different fuels and furnaces (unit: kg-CH_4/TJ)

Fuel				Code	Boilers	Industrial furnaces											Internal combustion engines		
					Boiler	Sintering furnace for smelting of metals (except copper, lead, and zinc)	Pelletizing furnace (steel and non-ferrous metal)	Blast furnace, converter furnace and open-hearth furnace (steel and non-ferrous metal)	Metal rolling furnace, metal treating furnace, metal forging furnace	Petroleum and gas furnaces	Catalytic regenerator	Brick kiln, ceramic kiln, and other kiln	Aggregate drying kiln, cement raw material drying kiln, brick raw material drying kiln	Other drying kilns	Other industrial furnaces	Gas turbine	Diesel engine	Gas engine, petrol engine
Coal	Steel Making Coal			$110	0.13	31	1.7	NA	13	13	NA	1.5	29	6.6	13	NA	NA	NA
	Coking Coal			$111														
	PCI Coal			$112														
	Imported Steam Coal			$130														
	Imported Coal for General Use			$131														
	Imported Coal for Power Generation			$132														
	Indigenous Produced Steam Coal			$135														
	Hard Coal, Anthracite & Lignite			$140														
Coal Products	Coke			$161	0.13	31	1.7	NA	13	13	0.054	1.5	29	6.6	13	NA	NA	NA
	Coal Tar			$162														
	Coal Briquette			$163														
	Coke Oven Gas			$171	0.23				0.43	0.16	NA				2.3	0.81	0.70	54
	Blast Furnace Gas			$172														
	Converter Furnace Gas			$175														
Oil	Crude Oil for Refinery			$210	0.10	31	1.7	NA	0.43	0.16	NA	1.5	29	6.6	0.83	0.81	0.70	54
	Crude Oil for Power Generation			$220														
	Bituminous Mixture Fuel			$221														
	Natural Gas Liquid & Condensate			$230														
Oil Products	Pure Naphtha			$281	0.26	31	1.7	NA	0.43	0.16	NA	1.5	29	6.6	0.83	0.81	0.70	54
	Reformed Feedstock Oil			$282														
	Gasoline			$310														
	Jet Fuel			$320														
	Kerosene			$330														
	Gas Oil or Diesel Oil			$340														
	Fuel Oil A			$351														
	Fuel Oil C			$355	0.10													
	Fuel Oil B			$356														
	Fuel Oil C for General Use			$357														
	Fuel Oil C for Power Generation			$358														
	Lublicant Oil			$365	0.26													
	Other Heavy Oil Products			$372	0.13				13	13	0.054				13	NA	NA	NA
	Petroleum Coke			$375														
	Galvanic Furnace Gas			$376	0.23				0.43	0.16	NA				2.3	0.81	0.70	54
	Refinary Gas			$380														
	Liquified Petroleum Gas			$390														
Natural Gas	Liquefied Natural Gas			$410	0.23	31	1.70	NA	0.43	0.16	NA	1.5	29	6.62	2.29	0.81	0.70	54
	Indigenous Natural Gas			$420														
	Indigenous Natural Gas			$421														
	Coal Mining Gas			$422														
	Boil Off Gas from Crude Oil			$423														
	Town Gas			$460	0.23	31	1.7	NA	0.43	0.16	NA	1.5	29	6.6	2.3	0.81	0.70	54
	Small Scale Community Gas			$470														
Biomass	Biomass Power Generation			$N131	29	29	29	29	29	29	29	29	29	29	29	29	29	29
	Biomass Energy Use	Solid	Energy and manufacturing industries	$N133	29	29	29	29	29	29	29	29	29	29	29	29	29	29
			Commercial, agriculture, etc.		290	290	290	290	290	290	290	290	290	290	290	290	290	290
		Liquid	Energy and manufacturing industries	$N134	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
			Commercial, agriculture, etc.		9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5
		Gas	Energy and manufacturing industries	$N135	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
			Commercial, agriculture, etc.		4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	Thermal Use of Black Liquor			$N136	4.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Thermal Use of Waste Woods			$N137	29	29	29	29	29	29	29	29	29	29	29	29	29	29

Table 3-21 N_2O emission factors for different fuels and furnaces (unit: kg-N_2O/TJ)

Fuel				Code	Boilers			Industrial furnaces					Internal-combustion engines		
					Boiler (other than fluidized-bed boiler)	Normal pressure fluidized-bed boiler	Pressurized fluidized-bed boiler	Blast furnace	Petroleum and gas furnaces	Catalytic regenerator	Coke oven	Other industrial furnace	Gas turbine	Diesel engine	Gas engine, petrol engine
Coal	Steel Making Coal			$110	0.85	54	0.85	NA	1.1	NA	NA	1.1	NA	NA	NA
	Coking Coal			$111											
	PCI Coal			$112											
	Imported Steam Coal			$130			5.2								
	Imported Coal for General Use			$131											
	Imported Coal for Power Generation			$132											
	Indigenous Produced Steam Coal			$135											
	Hard Coal, Anthracite & Lignite			$140			0.85								
Coal Products	Coke			$161	0.85	54	0.85	NA	1.1	7.3	NA	1.1	NA	NA	NA
	Coal Tar			$162											
	Coal Briquette			$163											
	Coke Oven Gas			$171	0.17	0.17	0.17	0.047	0.21	NA	0.14	1.2	0.58	2.2	0.85
	Blast Furnace Gas			$172				NA							
	Converter Furnace Gas			$175											
Oil	Crude Oil for Refinery			$210	0.22	0.22	0.22	NA	0.21	NA	NA	1.8	0.58	2.2	0.85
	Crude Oil for Power Generation			$220											
	Bituminous Mixture Fuel			$221											
	Natural Gas Liquid & Condensate			$230											
Oil Products	Pure Naphtha			$281	0.19	0.19	0.19	NA	0.21	NA	NA	1.8	0.58	2.2	0.85
	Reformed Feedstock Oil			$282											
	Gasoline			$310											
	Jet Fuel			$320											
	Kerosene			$330											
	Gas Oil or Diesel Oil			$340											
	Fuel Oil A			$351											
	Fuel Oil C			$355	0.22	0.22	0.22								
	Fuel Oil B			$356											
	Fuel Oil C for General Use			$357											
	Fuel Oil C for Power Generation			$358											
	Lublicant Oil			$365	0.19	0.19	0.19								
	Other Heavy Oil Products			$372	0.85	54	0.85		1.15	7.3		1.1	NA	NA	NA
	Petroleum Coke			$375											
	Galvanic Furnace Gas			$376	0.17	0.17	0.17		0.21	NA	0.14	1.2	0.58	2.2	0.85
	Refinary Gas			$380											
	Liquified Petroleum Gas			$390							NA				
Natural Gas	Liquefied Natural Gas			$410	0.17	0.17	0.17	NA	0.21	NA	NA	1.2	0.58	2.2	0.85
	Indigenous Natural Gas			$420							0.14				
	Indigenous Natural Gas			$421											
	Coal Mining Gas			$422											
	Boil Off Gas from Crude Oil			$423											
	Town Gas			$460	0.17	0.17	0.17	NA	0.21	NA	0.14	1.2	0.58	2.2	0.85
	Small Scale Community Gas			$470											
Biomass	Biomass Power Generation			$N131	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	Biomass Energy Use	Solid	Energy and manufacturing industries	$N133	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
			Commercial, agriculture, etc.												
		Liquid	Energy and manufacturing industries	$N134	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
			Commercial, agriculture, etc.												
		Gas	Energy and manufacturing industries	$N135	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
			Commercial, agriculture, etc.												
	Thermal Use of Black Liquor			$N136	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
	Thermal Use of Waste Woods			$N137	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8

➢ *Coke production*

CH_4 emissions from coke production come from two sources: CH_4 in combustion exhaust gas from gas leakage from the carbonization chamber to the combustion chamber, and CH_4 emitted from the coking furnace lid, the desulfurization tower, or the desulfurization recycling tower, in the carbonization process of coal.

- ***Combustion exhaust gas***

The concentration of CH_4 in the exhaust gas from coking furnaces operated by five companies at seven operating sites (surveyed by the Japan Iron and Steel Federation, actual results for FY1999) was

weighted by the production amount of coke to derive a weighted average, which was established as the emission factor. The emission factor is 0.089 [kg-CH_4/t].

- ***Coking furnace lid, desulfurization tower, and desulfurization recycling tower***

The Japan Iron and Steel Federation has had a voluntary plan in place since fiscal year 1997 to manage noxious atmospheric pollutants, and CH_4 emissions have been estimated from emissions of other substances from the lid of coking furnaces. The emission factor has been established by taking a weighted average using this data and the amount of production of coke.

Table 3-22 Emission factor of CH_4 from coking furnace lids, desulfurization towers, and desulfurization recycling towers

Item	Unit	1990-1996	1997-1999	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4 EFs	kgCH_4/t	0.238	0.180	0.119	0.043	0.039	0.040	0.037	0.032	0.031	0.042	0.045	0.039	0.039

* Emission factor change is assumed to be small for FY1990-1996. Therefore, actual data values for FY1995 is used for other years with no data. For FY1997-1999, it is assumed that values for 1998 and 1999 are the same as those of 1997. For FY2000 and on, actual data values are adopted.
Source: Japan Iron and Steel Federation data

- ***CH_4 emission factor for coke production***

The aforementioned Combustion Exhaust Gas and Coking Furnace Lids, Desulfurization Towers, and Desulfurization Recycling Towers have been added, and the resulting figure has been used as the emission factor.

- ***Activity Data***

➢ *Furnaces*

In the estimation of the activity data, data on the *General Survey of the Emissions of Air Pollutants* (see next page for the outline of this survey), which provides details of the fuel consumption for each type of furnace and fuel, and data on each fuel consumption statistics (the *Yearbook of the Current Survey of Energy Consumption*, energy consumption statistics, electric power statistics, and gas business production dynamic statistics) are used, because data on stationary combustion fuel consumption for each type of furnace are not available in the *General Energy Statistics*.

The fuel consumption by each sector (energy conversion, industry, commercial & others, and residential) for each type of fuels as presented in the *General Energy Statistics* was further divided among each furnace type proportionally to the fuel consumption ratio for each furnace estimated from the *General Survey of the Emissions of Air Pollutants* and from fuel consumption statistics to obtain the activity data for each sector, each fuel type and each furnace type. However, because the data in the *General Survey of the Emissions of Air Pollutants* do not differentiate between pressurized fluidized-bed boilers, normal pressure fluidized-bed boilers, and other boilers, the fuel consumption of these fluidized-bed boilers is calculated separately. The fuel consumption data of pressurized fluidized-bed furnaces were provided by the Federation of Electric Power Companies. The fuel consumption data of normal pressure fluidized-bed furnaces were provided from companies which had past operation records of normal pressure fluidized-bed furnaces since 1990.

The data of solid fuel boilers excluding fluidized-bed furnaces were estimated by subtracting the data of fluidized-bed furnace from the data of whole solid fuel boilers.

The exhaustive *General Survey of the Emissions of Air Pollutants* for all facilities emitting soot and smoke was carried out in fiscal years 1989, 1992, 1995, 1996, 1999, 2008 and 2011. For years in which the exhaustive *General Survey of the Emissions of Air Pollutants* was not carried out, the

percentages of fuel consumption accounted for by each furnace type were interpolated and extrapolated using the data obtained in the years when the exhaustive survey was carried out.

The procedure for calculating activity data is as follows:

1) Fuel consumption data from the *General Survey of the Emissions of Air Pollutants* is collated respectively for each fuel type, furnace type and sector.

2) The percentage of fuel consumption accounted for by each furnace type is calculated for each fuel type and sector.

3) Fuel consumption for different fuel types and sectors provided in the *General Energy Statistics* is multiplied by the percentage calculated in (2) to obtain fuel-specific, furnace-specific, and sector-specific activity data.

$$A_{ijk} = A_{EBik} \times w_{ijk}$$

$$w_{ijk} = A_{MAPijk} \Big/ \sum_m A_{MAPimk}$$

A_{ijk}	: Activity data for fuel type *i*, furnace type *j*, sector *k* [TJ]
A_{EBik}	: Fuel consumption for fuel type *i*, sector *k* from the *General Energy Statistics* [TJ]
w_{ijk}	: Ratio of furnace type *j* associated with consumption of fuel type *i* in sector *k*
i	: Fuel type
j	: Furnace type
k	: Sector
A_{MAPijk}	: Fuel consumption for fuel type *i*, furnace type *j*, sector *k* according to the *General Survey of the Emissions of Air Pollutants* [TJ]

- ***Outline of the General Survey of the Emissions of Air Pollutants***

The *General Survey of the Emissions of Air Pollutants* is a statistical survey conducted to (1) promote a reasonable and effective atmospheric environmental policy, (2) obtain information on current activities within the context of the Air Pollutant Control Law (e.g., the current status of regulation of stationary sources that emit soot and smoke in facilities registered to a local government and in facilities emitting ordinary soot or particular soot, and the current status of air pollutant control), (3) develop the submitted data on facilities emitting soot and smoke, and (4) estimate the amounts of air pollutant emissions from facilities that emit soot and smoke. This survey is conducted in the form of questionnaires. The response sheets and this survey's explanations are distributed to the target facilities mentioned above.

➢ *Coke production*

As the activity of CH_4 emissions from coke production, the inventory used the coke production amount given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics*, and the *Yearbook of Current Production Statistics*, both compiled by the Ministry of Economy, Trade and Industry.

Table 3-23 Coke production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Coke production	kt	47,338	42,279	38,511	38,009	38,720	38,867	36,551	34,140	37,036	34,875	35,024	35,082	33,785

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

➢ *Furnaces*

In case of using the default emission factor of the *2006 IPCC Guidelines*, the default uncertainties were applied. In case of using country specific emission factor, country specific uncertainties were established.

Since the uncertainty by fuel and sector of energy consumption in *the General Energy Statistics* were not available, upper value and lower value of uncertainty were established from standard variation of the rate of statistics error of "Coal, Coal Products", "Oil, Oil Products", Natural Gas, LPG" and "Renewable and Recovered Energy".

The uncertainties for fuel combustion at furnaces were estimated to be -38% to +50% for CH_4 emissions and -36% to +36% for N_2O emissions.

➢ *Coke production*

For the uncertainty of the emission factor for coke production, the uncertainty of fuel combustion emissions from the coking furnace and coking furnace lids were estimated separately. The uncertainty of fuel combustion emissions from the coking furnace and coking furnace lids was estimated as 98.5% and 61.8%, respectively. For the uncertainty of activity data, the standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used.

➢ *Incineration of waste for energy purposes and with energy recovery*

See section 7.4.3

- ***Time-series Consistency***

➢ *Furnaces*

The emissions were calculated in a consistent manner in all time-series.

The emission factors for CH_4 and N_2O have been calculated by a consistent estimation method since FY1990.

The activity data was used from data in the *General Energy Statistics* in all time-series, and the statistics were made by a consistent estimation method in all time-series.

➢ *Coke production*

For activity data, the same sources are used throughout the time-series. The emission factor is based on the information provided by the Japan Iron and Steel Federation estimated using a consistent methodology throughout the time-series. Therefore, CH_4 emissions from coke production have been estimated in a consistent manner throughout the time-series.

➢ *Incineration of waste for energy purposes and with energy recovery*

See section 7.4.3

d) Category-specific QA/QC and Verification

- ***QA/QC***

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission

factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

- ***Verification***

N_2O emission factors of fuel combustion currently used are established based on the actual measurements conducted in 1990s. Since then, the change of combustion conditions due to the progress of energy saving may change the emission factors, and the necessity of periodical review of the emission factors were pointed out by the Committee for the Greenhouse Gases Emissions Estimation Methods. In addition, the Expert Review Team strongly recommended that Japan provided additional information in its annual submission to transparently justify the appropriateness of the measurements to the current boiler types/technologies in the individual review of the 2013 submission. (FCCC/ARR/2013/JPN)

The actual measurement conducted in FY2009 is described here. The object of measurement was the N_2O emission factor of fluidized-bed boilers combusting solid fuels. As a result, the validity of measurements in 1990s is confirmed because the result of the measurement in FY2009 is almost the same level of the emission factor based on the measurements in the 1990s.

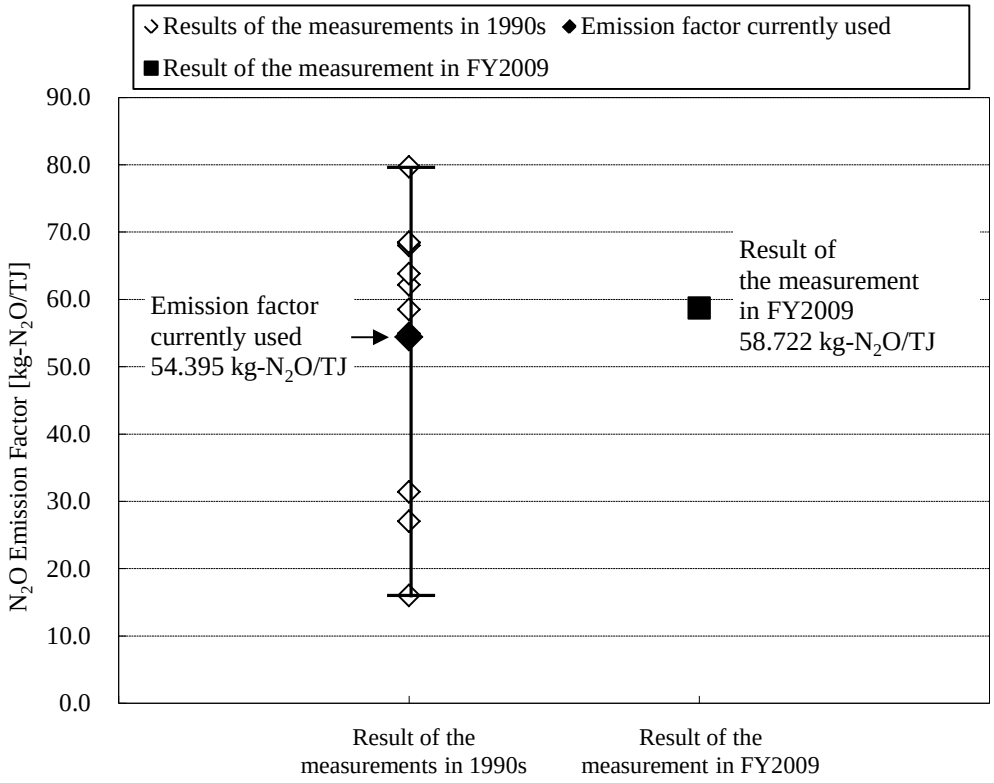


Figure 3-6 Comparison of the 1990s and FY2009 measurement results

e) Category-specific Recalculations

CH_4 and N_2O emissions in 2006, 2012 and 2013 were recalculated with a revision of the fuel consumption for 2006, 2012 and 2013 in the *General Energy Statistics.*

Also as for CH_4, the emissons in FY1990-2013 were recalcutated with a correction of calculation errors.

Updating the statistical data and improving the estimation methodology in the waste sector, CH_4 and

N_2O emissions in FY2013 were recalculated. See section 7.4.3 for details.

See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.6. CO_2 Emissions from Manufacturing Industries and Construction (1.A.2.:CO_2)

a) Category Description

This category provides the estimation methods for determining CO_2 emissions from iron and steel (1.A.2.a); non-ferrous metals (1.A.2.b); chemicals (1.A.2.c); pulp, paper, and print (1.A.2.d); food processing, beverages, and tobacco (1.A.2.e); non-metallic minerals (1.A.2.f) and other (1.A.2.g).

In FY2014, CO_2 emissions from this category accounted for 328,151 kt-CO_2, and represented 24.1% of Japan's total GHG emissions (excluding LULUCF). The iron and steel (1.A.2.a) accounts for 51.5%, and is the largest source within the manufacturing industries and construction category in FY2014.

The CO_2 emissions from manufacturing industries and construction (1.A.2) change due to production level and production efficiency of these industries and so on. The CO_2 emissions from this category are considered to have a moderate correlation with the *Indices of Industrial Production* (IIP; the Ministry of Economy, Trade and Industry), which is one of the representative indicators to show the production level. In the middle of 2000s, the CO_2 emissions were stable while the IIP increased, that implies the improvement of production efficiency due to the improvement of the operating ratio.

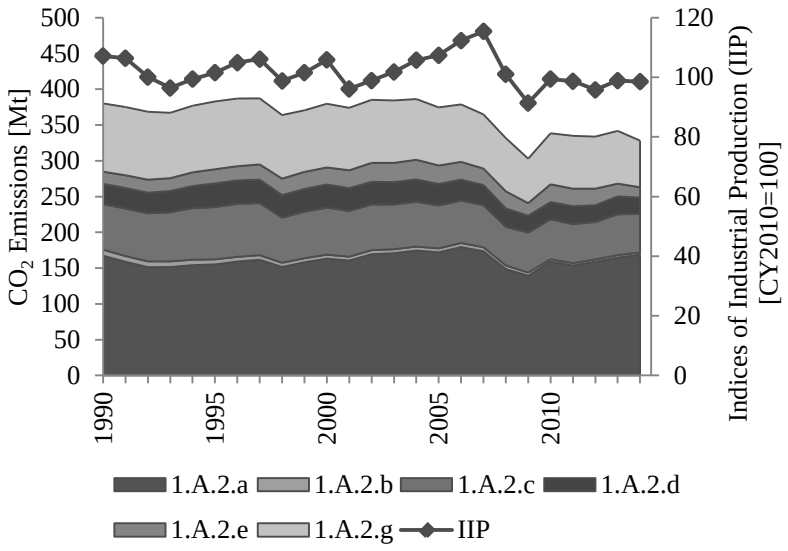


Figure 3-7 The trends of CO_2 emissions from Manufacturing Industries and Construction category (1.A.2) and related indicator

b) Methodological Issues

- ***Estimation Method***

The Tier 2 Sectoral Approach has been used in accordance with the decision tree of the *2006 IPCC Guidelines* to calculate emissions (Vol.2, Page 1.9, Fig. 1.2), as was the case for the energy industries (1.A.1). See Section 3.2.4. b) (1.A.1).

The energy consumption and emissions from waste incineration with energy recovery are reported in fuel combustion (1.A.) as "other fossil fuels" and "biomass" in accordance with the *2006 IPCC Guidelines*.

The estimation method, emission factors and activity data for emissions from waste incineration with energy recovery are the same as those used in the waste incineration (5.C.) in accordance with the *2006 IPCC Guidelines*. Please refer to Chapter 7 for further details on the estimation methods.

The CO_2 emissions from biomass are not included in the national totals but are reported in the CRFs as reference in accordance with the *2006 IPCC Guidelines*.

- ***Emission Factors***

The emission factors elaborated in the energy industries (1.A.1) are also used in this category. See Section 3.2.4. b) (1.A.1).

- ***Activity Data***

The data presented in the *General Energy Statistics* were used for activity data, as was the case for the energy industries (1.A.1).

Table 3-24 Energy consumptions in Manufacturing Industries and Construction category (1.A.2) (unit: PJ)

Fuel	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Liquid fuels	2,254	2,351	2,134	1,793	1,653	1,495	1,356	1,124	1,244	1,237	1,172	1,194	1,074
Solid fuels	2,187	2,102	2,198	2,278	2,346	2,316	2,063	1,931	2,143	2,076	2,134	2,203	2,201
Gaseous fuels	259	386	431	627	750	773	799	795	930	992	947	889	741
Other fossil fuels	85	99	114	173	180	194	192	192	197	199	203	205	209
Biomass	218	218	229	245	251	263	259	245	263	255	250	271	278
Total	5,004	5,155	5,106	5,116	5,180	5,041	4,669	4,287	4,777	4,759	4,706	4,762	4,504

The activity data for the manufacturing industry sectors were calculated by totaling the energy consumption from production activities in factories and offices (final energy consumption: #6xxxxx[7]), energy consumption related to non-utility power generation for use in one's own factories and offices (auto power generation: #25xxxx), and energy consumption related to steam production for use in own factories and offices (auto steam generation: #26xxxx) shown in the *General Energy Statistics*. Because the energy consumption for production activities in factories and offices contained a certain amount used as raw materials (non-energy and feedstock use: #95xxxx), this amount was subtracted.

The auto power generation and auto steam generation sectors are included in the energy transformation & own use sector in the *General Energy Statistics*. However, the *2006 IPCC Guidelines* allocates CO_2 emissions from energy consumption for power or steam generation to the sectors generating that power or steam. As such, these CO_2 emissions are added to those from each industry in the final energy consumption sector and are reported in 1.A.2.

[7] x indicates any number.

Table 3-25 shows the correspondence between the sectors of Japan's Energy Balance Table and those of the CRF (1.A.2).

Table 3-25 Correspondence between sectors of Japan's Energy Balance Table and of the CRF (1.A.2)

CRF		General Energy Statistics	
1A2	Manufacturing industries and construction		
1A2a	Iron and steel	Auto power generation; Manufacture of iron and steel	#253250
		Auto steam generation; Manufacture of iron and steel	#263220
		Final energy consumption; Manufacture of iron and steel	#629100
		Non-energy and feedstock use; Manufacture of iron, steel and steel products	#951560
1A2b	Non-ferrous metals	Auto power generation; Manufacture of non-ferrous metals and products	#253230
		Auto steam generation; Manufacture of non-ferrous metals and products	#263260
		Final energy consumption; Manufacture of non-ferrous metals and products	#629300
		Non-energy and feedstock use; Primary smelting and refining of copper, lead, zinc and aluminium	#951570
1A2c	Chemicals	Auto power generation; Manufacture of chemical and allied products	#253160
		Auto steam generation; Manufacture of chemical and allied products	#263160
		Final energy consumption; Manufacture of chemical and allied products	#626100
		Non-energy and feedstock use; Manufacture of petrochemical, ammonia, soda products	#951530
1A2d	Pulp, paper and print	Auto power generation; Manufacture of pulp, paper and paper products	#253140
		Auto power generation; Printing and allied industries	#253150
		Auto steam generation; Manufacture of pulp, paper and paper products	#263140
		Auto steam generation; Printing and allied industries	#263150
		Final energy consumption; Manufacture of pulp, paper and paper products	#624000
		Final energy consumption; Printing and allied industries	#625000
		Non-energy and feedstock use; Manufacture of pulp, paper and paper products, large scale	#951520
1A2e	Food processing, beverages and tobacco	Auto power generation; Manufacture of food	#253090
		Auto power generation; Manufacture of beverages, tobacco and feed	#253100
		Auto steam generation; Manufacture of food	#263090
		Auto steam generation; Manufacture of beverages, tobacco and feed	#263100
		Final energy consumption; Manufacture of food, beverages, tobacco and feed	#621000
1A2f	Non-metallic minerals	IE (1A2g)	-
1A2g	Other	Auto power generation; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#251010-#251040])	#251000
		Auto power generation; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#252000
		Auto steam generation; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#261010-#261040])	#261000
		Auto steam generation; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#262000
		Final energy consumption; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#611000])	#610000
		Final energy consumption; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#620000
		Non-energy and feedstock use; Agriculture, fishery, mining and construction (except for agriculture, forestry and fishery)	#951100
		Non-energy and feedstock use; Manufacturing industry, large scale (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#951500
		Non-energy and feedstock use; Manufacturing industry, small and medium scale	#951700

#95xxxx items are subtracted as non-energy use activities.

c) Uncertainties and Time-series Consistency

See Section 3.2.4. c).

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The CO_2 emissions in FY1993, 2006, 2012 and 2013 were recalculated with a revision of the carbon emission factors, the gross calorific values and the fuel consumption of the *General Energy Statistics*.

Updating the statistical data and improving the estimation methodology in the waste sector, CO_2 emissions in FY1990-FY2013 were recalculated. See section 7.4.3 for details.

See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.7. CH_4 and N_2O Emissions from Manufacturing Industries and Construction (1.A.2.:CH_4, N_2O)

a) Category Description

This category provides the estimation methods for determining CH_4 and N_2O emissions from iron and steel (1.A.2.a); non-ferrous metals (1.A.2.b); chemicals (1.A.2.c); pulp, paper, and print (1.A.2.d); food processing, beverages, and tobacco (1.A.2.e); non-metallic minerals (1.A.2.f); and other (1.A.2.g).

This category also provides the estimation methods for determining CH_4 and N_2O emissions from off-road vehicles, work ships and other machinery of manufacturing industries and construction.

b) Methodological Issues

- ***Estimation Method***

➢ *Furnaces*

Same with Energy Industries (1.A.1), CH_4 and N_2O emissions from fuel combustion in this category are calculated by using Tier 3 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol.2, Page 1.9, Fig. 1.2). See 3.2.5. b) (1.A.1).

➢ *Off-road vehicles and other machinery*

The emissions from off-road vehicles, work ships and other machinery of manufacturing industries and construction are estimated by Tier 1 in accordance with the decision tree of the *2006 IPCC Guidelines* to calculate emissions (Vol.2, Page 3.34, Fig. 3.3.1) and reported in each sub-category of manufactring industries and construction (1.A.2).

➢ *Incineration of waste for energy purposes and with energy recovery*

See section 7.4.3.

● ***Emission Factors***

➢ *Furnaces*

The emission factors which were established in Energy Industries (1.A.1) were used. See Table 3-20 and Table 3-21, See 3.2.5. b) (1.A.1).

➢ *Off-road vehicles and other machinery*

The emission factors of Fuel oil A of work ships were estimated from the default values of Ocean-going Ships which were provided in the *2006 IPCC Guidelines* (Vol.2, page 3.50, Table 3.5.3) after conversion to the gross calorific value. The emission factors of gasoline, diesel oil and fuel oil A for other than work ships were estimated from the values of *EMEP/EEA air pollutant emission inventory guidebook 2013* (Table 3-1, 1.A.2.f.ii and 1.A.4.a.ii) after conversion to the gross calorific value.

Table 3-26 Emission factors of CH_4 and N_2O for off-road vehicles and other machinery in manufacturing industries and construction (1.A.2) (Unit: kg/TJ)

Fuel	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	References
Gasoline	$kgCH_4/TJ$	41.0	40.9	40.9	40.9	41.0	41.0	41.0	41.0	41.0	41.0	41.0	42.4	42.4	EMEP/EEA air pollutant emission inventory guidebook 2013 Table 3-1
	kgN_2O/TJ	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	
Diesel oil (includes fuel oil A used for other than ships)	$kgCH_4/TJ$	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	
	kgN_2O/TJ	2.9	2.9	2.9	3.0	3.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	
Fuel oil A for ships	$kgCH_4/TJ$	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2006 IPCC Guidelines Table 3.5.3
	kgN_2O/TJ	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	

● ***Activity Data***

➢ *Furnaces*

The fuel consumption of mobile combustion and stationary combustion are estimated by multiplying the fuel consumption of each category and each fuel type in the *General Energy Statistics* by the ratios of mobile and stationary combustion on the Table 3-27, which are the survey results executed by the Ministry of the Environment in FY2014 and FY2015.

In addition, the fuel consumption, which is estimated by multiplying the fuel consumption of stationary combustion obtained as described above by the fuel consumption ratio of each furnace type, is assumed as the activity data for the stationary combustion (namely combustion in furnaces). Same with Energy Industries (1.A.1), the ratio of fuel consumption of each furnace type was estimated from data on the *General Survey of the Emissions of Air Pollutants* and data on each fuel consumption statistics (the *Yearbook of the Current Survey of Energy Consumption*, energy consumption statistics, electric power statistics, and gas business production dynamic statistics). See 3.2.5. b) (1.A.1).

➢ *Off-road vehicles and other machinery*

The fuel consumption, which is estimated by multiplying the fuel consumption of each category and each fuel type in the *General Energy Statistics* by the fuel consumption ratio in the Table 3-27, is assumed to be the activity data of the mobile combustion, namely the off-road vehicles and other machinery.

In relation to the Table 3-27, all fuel consumption of fuel oil A and diesel oil of construction in the *General Energy Statistics* were used for activity data of mobile combustion. According to Japan

Federation of Construction Contractors, the fuel consumption of electric generator as stationary combustions is included in the value of fuel oil A and diesel oil of construction, however the emission factors of mobile combustion are applied for electric generator, because a combustion engine of electric generator is similar with diesel engine.

Table 3-27 Fuel consumption ratio of mobile combustion and stationary combustion in manufacturing industries and construction (1.A.2)

CRF code	Category in General Energy Statistics	Gasoline		Diesel oil		Fuel oil A		
		Mobile com-bustion	Station-ary com-bustion	Mobile com-bustion	Station-ary com-bustion	Mobile com-bustion (ships)	Mobile com-bustion	Station-ary com-bustion
1A2a	Manufacture of iron and steel	1%	99%	16%	84%			
1A2b	Manufacture of non-ferrous metals and products	24%	76%	1%	99%			
1A2c	Manufacture of chemical and allied products	100%	0%	1%	99%			
1A2d	Manufacture of pulp, paper and paper products	74%	26%	10%	90%			
	Printing and Allied Industries			0%	100%			
1A2e	Manufacture of food, beverages, tobacco and feed			1%	99%			
1A2g	Manufacture of Ceramic, Stone and Clay Products	7%	93%	1%	99%			
	Manufacture of Fabricated Metal Products			1%	99%			
	Manufacture of Machinery	2%	98%	1%	99%			
	Mining, Quarrying of Stone and Gravel			100%	0%	17%	25%	58%
	Manufacture of Lumber and Wood Products, except Furniture and Fixtures			2%	98%			
	Construction Work Industry			100%	0%	0%	100%	0%
	Manufacture of Textile Mill Products	100%	0%					
	Manufacture of Leather Tanning, Leather Products and Fur Skins			0%	100%			
	Manufacture of Furniture and Fixtures			0%	100%			
	Manufacture of Rubber Products			0%	100%			
	Manufacture of Plastic Products, except Otherwise Classified			0%	100%			
	Miscellaneous Manufacturing Industry			4%	96%			
	Duplication Adjustment for Manufacturing	0%	100%					

(Source) Estimated based on “Actual condition survey of GHG emissions from manufacturing industry, Fiscal year 2014” and “Actual condition survey of GHG emissions from non-manufacturing industry, Fiscal year 2015”, both by the Ministry of the Environment.

c) Uncertainties and Time-series Consistency

See 3.2.5. c).

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

CH_4 and N_2O emissions in FY1993, 2006, 2012 and 2013 were recalculated with a revision of the fuel consumption for FY1993, 2006, 2012 and 2013 in the *General Energy Statistics.*

N_2O emissions in FY2000-2013 were recalculated with a revision of the fuel consumption data for normal pressure fluidized-bed boilers.

CH_4 and N_2O emissions in FY1990-2013 were recalculated with an establishment of the estimation method of the emissions from mobile combustion source such as off-road vehicles and other machinery in manufacturing industries and construction.

Updating the statistical data and improving the estimation methodology in the waste sector, CH_4 and N_2O emissions in FY1990-2013 were recalculated. See section 7.4.3 for details.

See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.8. CO_2 Emissions from Transport (1.A.3.:CO_2)

a) Category Description

This category provides the methods used to estimate CO_2 emissions from civil aviation (1.A.3.a), road transportation (1.A.3.b), railways (1.A.3.c), navigation (1.A.3.d), and other transportation (1.A.3.e).

In 2014, CO_2 emissions from this category accounted for 208,287 kt-CO_2, and represented 15.3% of Japan's total GHG emissions (excluding LULUCF). The road transportation (1.A.3.b) accounts for 89.6% and is the largest within the Transport category in FY2014.

CO_2 emissions from this category change due to traffic volume, transport efficiency and so on. The CO_2 emissions from Road transportation (1.A.3.b), which is the largest source in Transport (Mobile combustion) (1.A.3.) category, are considered to have a moderate correlation with the distance traveled given in the Ministry of Land, Infrastructure, Transport and Tourism's *Statistical Yearbook of Motor Vehicle Transport*. Although CO_2 emissions from road transportation subcategory increased in 1990s due to an increase in distance traveled, the emissions have decreased in the 2000's due to decrease in distance traveled, improvement of transport efficiency and so on.

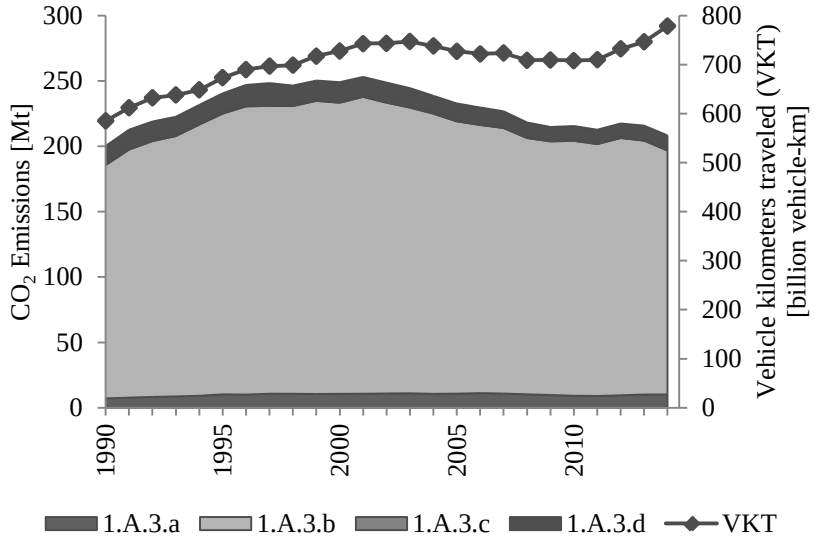


Figure 3-8 The trends of CO_2 emissions from Transport (Mobile Combustion) (1.A.3.) and related indicator

b) Methodological Issues

- ***Estimation Method***

➢ *Fuels other than lubricants*

The Tier 2 Sectoral Approach has been used in accordance with the decision tree of the *2006 IPCC Guidelines* to calculate emissions (Vol.2, Page 1.9, Fig. 1.2), as was the case for the energy industries (1.A.1). See 3.2.4. b)).

➢ *Lubricants*

CO_2 is emitted by oxidation of lubricants in engines during use. According to the *2006 IPCC Guidelines* (Vol.3, page 5.6), in the case of 2-stroke (2-cycle) engines, where the lubricant is mixed with another fuel and thus on purpose co-combusted in the engine, the emissions should be estimated and reported as part of the combustion emissions in the energy sector. 2-stroke engine oil for automobile and marine diesel engine oil correspond to be reported in the energy sector. The emissions are estimated by the following equation. The emissions from 2-stroke engine oil are reported in 1.A.3.b and those from marine diesel oil are reported in 1.A.3.d.

$$E = \sum_i \left(LC_i * CC_i * ODU_i * 44/12 \right)$$

E	: CO_2 emissions from lubricants oxidized during use (kt-CO_2)
LC_i	: Consumption of lubricant (TJ)
CC_i	: Carbon content of lubricant (kt-C/TJ)
ODU_i	: Oxidized During Use (ODU) factor
i	: Lubricant type (2-stroke engine oil for automobile and marine diesel engine oil)

- ***Emission Factors***

➢ *Fuels other than lubricants*

The emission factors elaborated in the energy industries (1.A.1) are also used in this category. See 3.2.4. b).

The carbon emission factor for liquid fuels (diesel oil) in 1.A.3.b (Road transportation) is the lowest in Annex I Parties for two reasons. One is because the quality standard for diesel oil in Japan is different from other countries. Crude oil with high sulfur content imported from the Middle East must be decomposed and go through ultra-deep desulfurization to become low-sulfur diesel oil (<10 ppm) according to Japanese automobile exhaust gas regulations. The other reason is because gas oil used for purposes other than road transport is called "fuel oil A" to distinguish it from diesel oil. The carbon balance of Japanese petroleum refineries including diesel oil and fuel oil A nearly matches according to statistics, so these carbon emission factors are not irregular.

Please refer to the quality standard for diesel oil in Japan provided in Annex 4 (A4.3).

➢ *Lubricants*

The carbon content *CC* is the carbon emission factor of lubricants elaborated in the energy industries (1.A.1). The ODU factor is 1.0 assuming that all lubricants are combusted.

- ***Activity Data***

Table 3-28 Energy consumptions in Transport (Mobile Combustion) (1.A.3.) (unit: PJ)

Fuel	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Liquid fuels	2,954	3,546	3,675	3,436	3,390	3,348	3,222	3,173	3,184	3,142	3,213	3,136	3,026
Solid fuels	0.033	0.031	0.046	0.037	0.033	0.034	0.038	0.044	0.043	0.043	0.040	0.039	0.039
Gaseous fuels	0.003	0.141	1.1	4.0	4.4	4.6	4.9	4.8	4.7	4.6	4.3	4.0	3.9
Other fossil fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	2,954	3,546	3,677	3,440	3,395	3,352	3,227	3,178	3,188	3,146	3,217	3,140	3,030

➢ *Fuels other than lubricants*

The data given in the *General Energy Statistics* were used for activity data.

The values subtracting final energy consumption reported under ‘non-energy and feedstock use’ [#953000] from energy consumption reported under ‘air transport’ [#814000] [#854000], ‘road transport’ [#811000] [#851000] [#811500] [#819000] [#859000], ‘railway transport’ [#812000] [#852000] and ‘water transport’ [#813000] [#853000] in Japan’s Energy Balance Table (*General Energy Statistics*) are used for activity data. Because energy consumption reported under ‘non-energy and feedstock use’ was used for purposes other than combustion and was considered not emitting CO_2, these values were deducted. (see Table 3-29)

Table 3-29 Correspondence between sectors of Japan's Energy Balance Table and those of the CRF (1.A.3)

CRF			General Energy Statistics	
1A3	Transport			
	1A3a Domestic aviation		Final energy consumption; Passenger; Air passenger transport	#814000
			Final energy consumption; Freight; Air freight transport	#854000
			Non-energy and feedstock use; Transportation (air)	#953000
	1A3b Road transportation			
		i Cars	Final energy consumption; Passenger; Passenger vehicle	#811000
			Final energy consumption; Passenger; Estimation discrepancy	#819000
			Non-energy and feedstock use; Transportation (passenger vehicle)	#953000
		ii Light duty trucks	IE (1A3biii)	-
		iii Heavy duty trucks and buses	Final energy consumption; Passenger; Bus	#811500
			Final energy consumption, Freight; Freight truck and lorry	#851000
			Final energy consumption; Freight; Estimation discrepancy	#859000
			Non-energy and feedstock use; Transportation (bus, freight truck and lorry)	#953000
		iv Motorcycles	IE (1A3bi, 1A3biii, 1A4a)	-
		v Other	IE (1A3biii)	-
	1A3c Railways		Final energy consumption; Passenger; Railway passenger transport	#812000
			Final energy consumption; Freight; Railway freight transport	#852000
			Non-energy and feedstock use; Transportation (railways)	#953000
	1A3d Domestic navigation		Final energy consumption; Passenger; Water passenger transport	#813000
			Final energy consumption; Freight; Water freight transport	#853000
			Non-energy and feedstock use; Transportation (water)	#953000
	1A3e Other transportation		NO	-

#95xxxx items are subtracted as non-energy use activities.

- *Lubricants*

The sales of engine oils for automobiles and navigation are estimated from the total sales of lubricants, and then they are used to estimate the consumptions of total loss type engine oils.

The sales of engine oils for automobile (gasoline engine oil and diesel engine oil) and marine diesel engine oil in cubic volume basis are estimated by multiplying *DS*, or the domestic sales of all lubricants shown in *Yearbook of Mineral Resources and Petroleum Products Statistics* and *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* (both from the Ministry of Economy, Trade and Industry), by R_i, or the proportion of each of engine oil to all lubricants sold to consumers (, wholesalers and retailers) estimated from these yearbooks. They are multiplied by R_{TLi}, or the proportions of total loss type lubricants to each of engine oil, to obtain the consumptions of total loss type engine oils. R_{TLi} is derived by dividing the productions and imports of 2-stroke engine oils and marine cylinder oil in fiscal year 2011 shown in the *Report on the Subsidized Project of Environmental Measures of Lubricants Fiscal Year 2012* (Japan Lubricating Oil Society) by the domestic sales of engine oils for automobiles and marine diesel engine oil estimated above, respectively (0.92% for engine oils for automobiles and 83% for marine diesel engine oil).

LC_i, or the consumptions of total loss type engine oils in quantity of heat basis, are obtained by converting the consumptions in cubic volume basis by using the gross calorific values of lubricants shown in the *General Energy Statistics* (Agency for Natural Resources and Energy), and they are set as activity data.

$$LC_i = DS * R_i * R_{TLi} * GCV$$

LC_i : Consumption of each of engine oil (TJ)
DS : Domestic sales of all lubricants (1,000kl)
R_i : Proportion of each of engine oil to all lubricants sold to consumers (, wholesalers and retailers)

R_{TLi} : Proportions of total loss type lubricants to each of engine oil
i : Lubricant type (engine oils for automobile and marine diesel engine oil)
GCV : Gross calorific values of lubricants (GJ/kl)

Table 3-30 Consumption of total loss type engine oils

Item		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Two stroke engine oil for automobiles	LC_1	1000 kl	5.1	5.4	5.2	4.8	5.0	4.7	4.5	4.6	4.6	4.3	3.9	3.9	3.9
Cylinder oil for navigation	LC_2	1000 kl	132	137	178	155	149	143	131	124	115	100	90	87	82
Total sales of lubricants	DS	1000 kl	2,439	2,335	2,192	2,047	2,054	1,938	1,750	1,681	1,763	1,695	1,538	1,531	1,521
Proportion of sales of engine oils for automobiles	R_1	-	23%	25%	26%	26%	26%	27%	28%	30%	28%	28%	28%	28%	28%
Proportion of sales of marine diesel engine oils	R_2	-	6.5%	7.1%	9.8%	9.1%	8.7%	8.9%	9.0%	8.9%	7.9%	7.1%	7.1%	6.8%	6.5%
Gross calorific value of lubricants	GCV	GJ/kl	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2

c) Uncertainties and Time-series Consistency

See 3.2.4. c).

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The CO_2 emissions in FY2006, 2012 and 2013 were recalculated with a revision of the carbon emission factors, the gross calorific values and the fuel consumption of the *General Energy Statistics*. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.9. CH_4 and N_2O Emissions from Transport (1.A.3.:CH_4 , N_2O)

This section provides the estimation methods for CH_4 and N_2O emissions from domestic aviation (1.A.3.a), road transportation (1.A.3.b), railways (1.A.3.c), domestic navigation (1.A.3.d), and other transportation (1.A.3.e).

3.2.9.1. Domestic Aviation (1.A.3.a.)

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from energy consumption in domestic aviation. Greenhouse gases associated with the domestic operation of Japanese airliners are mainly emitted from jet fuels. In addition, a small amount of aviation gasoline used by light aircraft and helicopters is also a source of CH_4 and N_2O emissions.

b) Methodological Issues

- ***Estimation Method***

In accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 3.60, Fig. 3.6.1), the emissions from jet fuel for jet aircraft is calculated using the Tier 2 method by aggregating the emissions estimated by aircraft type, and the emissions from aviation gasoline, which is used for light aircraft and helicopters, is estimated by the Tier 1 method from the total domestic fuel consumption.

However, as for jet fuel, the activity data by aircraft type is not available prior to FY2000. Therefore, the weighted average emission factor for all type of aircraft in FY2001, is multiplied by the total activity data to estimate the emissions prior to FY2000.

CH_4 and N_2O emissions by aircraft type associated with LTO of domestic airliners using jet fuel
= Emission factor per LTO 1 cycle by aircraft type of domestic airliner
× Number of LTO cycles by aircraft type on domestic routes

LTO: Landing and take-off

CH_4 and N_2O emissions by aircraft type from domestic airliner during cruising using jet fuel
= Emission factor associated with jet fuel consumption
× Jet fuel consumption during cruising on domestic routes

CH_4 and N_2O emissions associated with flight of gasoline-powered domestic aircraft
= Emission factor associated with the consumption of aviation gasoline
× Consumption of aviation gasoline by aircraft on domestic routes

- ***Emission Factors***

➢ *Jet fuel*

The default values given in the *2006 IPCC Guidelines* (Vol. 2, page 3.70, Table 3.6.9) are used for the emission factors of CH_4 and N_2O during LTO. As for during cruising, the default values given in the *2006 IPCC Guidelines* (Vol. 2, page 3.64, Table 3.6.5) are used. (See Table 3-31)

➢ *Aviation gasoline*

The default values given in the *2006 IPCC Guidelines* (Vol. 2, page 3.64, Table 3.6.5) are used for emission factors of CH_4 and N_2O (see Table 3-31).

Table 3-31 CH_4 and N_2O emission factors for aircraft

Type of aircraft (fuel)	Flight phase	CH_4	N_2O
Jet aircraft (Jet fuel)	LTO	Varies per aircraft type (see Table 3-32)	
	Cruise	- [1)]	2 [kg-N_2O/TJ]
Other than jet aircraft (Aviation gasoline)	-	0.5 [kg-CH_4/TJ]	2 [kg-N_2O/TJ]

LTO: Landing and take-off
Source: *2006 IPCC Guidelines*, Volume 2, page 3.64, Table 3.6.5
1) Excluded from calculations, as the emissions are assumed as negligible in the guideline.

Table 3-32 CH_4 and N_2O emission factors and fuel consumption for major types of jet aircraft

Aircraft type	CH_4 emission factor [kg/CH_4/LTO] [1)]	N_2O emission factor [kg/N_2O/LTO] [1)]	Fuel consumption [kg/LTO] [1)]
B737-300/400/500	0.08	0.1	780
B737-800	0.07	0.1	880
B747SR (B747-100, -200, -300)	4.84 [2)]	0.4 [2)]	3,440 [3)]
B747-400	0.22	0.3	3,240
B767-300	0.12	0.2	1,780
B777-200/300	0.07	0.3	2,560
A320	0.06	0.1	770
Average of emission factors of all aircraft types in FY 2001 (adopted for the emission factor of all types of aircraft before 2001)	0.34	0.15	—

Source: *2006 IPCC Guidelines*, Vol, 2, page 3.70, Table 3.6.9
1) LTO: Landing and take-off
2) Maximum value of B747-100, -200, and -300 is used
3) Average value of B747-100, -200, and -300 is used

- ***Activity Data***

➢ *Jet fuel*

The number of LTO (landing and take-off) by aircraft type given in the *PRTR Outside Notification Emissions Estimated Data* of the Ministry of the Environment is used as activity data for LTO. However, these data involve the international flights LTO, thus the number of international flights LTO is subtracted for each aircraft type used for both domestic and international flights in same ratio of domestic and international flights from total LTO, so as to keep the total number of domestic LTO in the *Airport Management Status Study Report* of the Ministry of Land, Infrastructure, Transport and Tourism.

The fuel consumption during LTO is calculated by multiplying the fuel amount consumed per one LTO, which is given in the 2006 *IPCC Guidelines* for each aircraft type, by the number of LTO given above.

The fuel consumption for cruising is estimated by subtracting the amount of jet fuel consumed during LTO from the total jet fuel consumption in the *Statistical Yearbook of Air Transport* of the Ministry of Land, Infrastructure, Transport and Tourism.

➢ *Aviation gasoline*

The consumption of gasoline in the domestic aviation, which is taken from the *General Energy Statistics* of the Agency for Natural Resources and Energy, is used for activity data.

Table 3-33 Activity data used for emission estimates of aircraft

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of LTO cycle	1000 LTO	669	783	865	895	925	920	900	892	882	882	938	993	1,006
Jet fuel comsumption during cruise	1000 kl	1,621	2,425	2,742	3,031	3,147	2,984	2,945	2,791	2,629	2,589	2,758	2,933	2,943
Aviation gasoline comsumption	1000 kl	5.3	6.0	4.3	7.7	8.2	4.2	2.8	2.4	1.9	1.7	1.9	1.9	1.7

Table 3-34 Number of LTO cycle of major types of jet aircraft [1000 LTO]

Aircraft type	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
B737-300/400/500	123	103	108	109	91	90	84	130	129	131	134
B737-800	NO	NO	NO	4	33	59	97	89	97	118	120
B747SR	43	30	30	27	6	2	3	2	1	1	1
B747-400	56	54	56	62	41	36	22	15	16	14	14
B767-300	146	103	77	79	77	102	101	105	95	87	89
B777-200/300	69	76	81	89	91	87	89	86	91	93	95
A320	59	47	58	54	49	57	48	55	88	95	97

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for the uncertainty of emission factors, the default values by each aircraft type per one LTO given in the *2006 IPCC Guidelines* (Tier 2) are applied for the emission factors, and the estimation is considered to be more accurate than Tier 1. Therefore the values of the Tier 1 default uncertainty in the guideline (CH_4: -57% to +100%, N_2O: -70% to +150%) are considered to be the upper limit, and are adopted. As for the uncertainty of activity data, because the *Airport Management Status Study Report* is a complete survey executed by the Ministry of Land, Infrastructure, Transport and Tourism, the values in the *2006 IPCC Guidelines* (-5% to +5%) are used. As a result, the uncertainty of the emissions from domestic aviation is evaluated as -57% to +100% for CH_4, and -70% to +150% for N_2O.

- ***Time-series Consistency***

For the emission factors per LTO, the same value is used for every fiscal year since FY2001 by each aircraft type. For the emission factors prior to FY2000, because the activity data by each aircraft type are not available, the average emission factor for all aircraft type is established from the FY2001 data, and it is used for the fiscal years back to FY1990. In addition, the jet fuel consumption in the *Statistical Yearbook of Air Transport* and the aviation gasoline consumption in the *General Energy Statistics* are used as activity data consistently from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The emissions from jet fuel for the period FY1993-1996 were recalculated due to some corrections of inputted activity data. The emissions from aviation gasoline for the period FY1990-2013 were recalculated due to a revision of calorific values. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.9.2. Road Transportation (1.A.3.b.)

Emissions from automobiles in Japan are calculated for the following vehicle categories:

Table 3-35 Reporting categories and definitions of emissions from automobiles

Vehicle type	Definition	Fuel type for emission reporting			
		Gasoline	Diesel	LPG	Natural gas
Light passenger vehicle	Light vehicle used for transportation of people.	Yes	-	-	-
Passenger vehicle	Regular vehicle or small vehicle used for transportation of people, with a capacity of 10 persons or less.	Yes	Yes	Yes	Yes
Bus	Regular vehicle or small vehicle used for transportation of people, with a capacity of 11 persons or more.	Yes	Yes	-	Yes
Light cargo truck	Light vehicle used for transportation of cargo	Yes	-	-	-
Small cargo truck	Small vehicle used for transportation of cargo.	Yes	Yes	-	Yes (Cargo truck)
Regular cargo truck	Regular vehicle used for transportation of cargo.	Yes	Yes	-	
Special-purpose vehicle	Regular, small or light vehicle used for special purposes, including flushers, advertising vans, hearses, and others.	Yes	Yes	-	Yes
Motorcycle	Two-wheeled vehicle	Yes	-	-	-

Table 3-36 Correspondence between vehicle type and sectors of the CRF (1.A.3.b)

CRF	Vehicle type, or notation key
1A3b Road transportation	
i. Cars	Light passenger vehicle, passenger vehicle, and motorcycle
ii. Light duty trucks	IE (included in iii. Heavy duty trucks and buses)
iii. Heavy duty trucks and buses	Bus, light cargo truck, small cargo truck, regular cargo truck, and special-purpose vehicle
iv. Motorcycles	IE (included in i. Cars)
v. Other	IE (included in iii. Heavy duty trucks and buses)

Different estimation methods are used between motorcycles and other road transportation vehicles, Road transportation vehicles other than motorcycles (3.2.4.2.a) and Motorcycles (3.2.4.2.b) are separately described in the following sections.

3.2.9.2.a. Road transportation: vehicles other than motorcycles

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from road transportation vehicles other than motorcycles, namely light passenger vehicles, light cargo trucks, passenger vehicles, buses, small cargo trucks, regular cargo trucks, and special-purpose vehicles.

b) Methodological Issues

- ***Estimation Method***

The emissions are calculated by multiplying the distance traveled of each vehicle type by the emission factors of each vehicle type established by using the Tier 3 method, in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 3.14, Fig. 3.2.3).

- ***Emission Factors***

The emission factors for CH_4 and N_2O are established for each fuel type for each vehicle type, using the data shown in Table 3-37.

For "JAMA data", the emission factors are established on the basis of the raw emission factors data provided by Japan Automobile Manufacturers Association. The raw emission factors are arranged as combined mode emission factors[8] by car registration year. The emission factors are estimated by averaging the arranged emission factors of JAMA weighted by the number of vehicles of each car registration year of each car type (see Table 3-38, Table 3-39).

For "Measured data", the emission factors are established on the basis of actual Japanese data. The emission factors are developed as weighted averages calculated from emission factors estimated by each class of running speed and proportion of distance traveled for each class of running speed given in the Ministry of Land, Infrastructure, Transport and Tourism's *Road Transport Census*. The emission factors reflect the actual operation of vehicles in Japan because the proportion of distance traveled by each class of running speed during rush hour was applied.

The N_2O emission factors for natural gas trucks are established from actual measurement data. The emission factors are developed as weighted averages calculated from emission factors of each class of

[8] The JAMA data were provided by test mode. The emission factors were calculated using "combined driving mode". "Combined JC08 driving mode" = "hot start driving mode" ×0.75 + "cold start driving mode" ×0.25

running speed based on actual measurements taken in Japan and the proportion of distance traveled for each class of running speed reported in the *Road Transport Census* (Ministry of Land, Infrastructure, Transport and Tourism). However, N_2O emission factors for passenger vehicles, buses, and special-purpose vehicles, and CH_4 emission factors for special-purpose vehicles are established by the method indicated in Table 3-37, because of the absence of actual measurement data in Japan.

The detailed method for establishing the emission factors is described in the *Greenhouse Gases Estimation Methods Committee Report – Transportation* (Ministry of the Environment; February, 2006).

Table 3-37 Data source of the emission factors of vehicle

Fuel / Vehicle type	Gasoline		Diesel		Natural gas	
	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Light passenger vehicle	JAMA data	JAMA data				
Passenger vehicle	JAMA data	JAMA data	JAMA data	JAMA data	JAMA data	The EF of small cargo truck is used considering the standard of vehicle type
Bus	2006GL	2006GL	Measured data	2006GL	JAMA data	Established by correcting the EF of regular cargo truck by the equivalent inertial weight ratio considering vehicle weight.
Light cargo truck	JAMA data	JAMA data				
Small cargo truck	JAMA data	JAMA data	JAMA data	JAMA data		Established based on the actual measured data (classified as cargo truck)
Regular cargo truck	2006GL	2006GL	JAMA data	JAMA data	JAMA data	
Special-purpose vehicle	2006GL	2006GL	Measured data	2006GL	Established using the corrected travel distance ratio by each running speed, considering the EFs by each speed of regular cargo truck and running pattern of special-purpose vehicle.	

1) JAMA data: Calculated by using driving mode test data provided by Japan Automobile Manufacturers Association
2) Measured data: Using actual Japanese data other than the above JAMA data
3) 2006GL: Using the default values in the *2006 IPCC Guidelines*.
4) EFs of LPG vehicle are same as those of gasoline passenger vehicle.

Table 3-38 CH_4 emission factors for road transportation [mg-CH_4/km]

Fuel	Vehicle type	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light passenger vehicle	8.3	8.3	8.2	6.9	6.5	6.1	5.8	5.4	5.1	4.9	4.6	4.3	4.1
	Passenger vehicle (including LPG)	15	15	14	11	10	10	9.2	8.5	7.9	7.4	6.9	6.3	5.9
	Bus	14												
	Light cargo truck	19	19	18	12	10	9.3	8.4	7.8	7.2	6.7	6.3	5.8	5.5
	Small cargo truck	21	21	21	15	13	12	11	10	10	8.9	8.3	7.8	7.4
	Regular cargo truck	14												
	Special-purpose vehicle	14												
Diesel	Passenger vehicle	11	12	13	13	13	13	13	13	13	13	13	13	13
	Bus	19	18	17	17	17	17	17	17	17	17	17	17	17
	Small cargo truck	10	11	10	8.7	8.6	8.6	8.5	8.5	8.5	8.4	8.4	8.4	8.3
	Regular cargo truck	17	16	15	14	13	13	13	12	12	11	11	10	10
	Special-purpose vehicle	17	15	13	13	13	13	13	13	13	13	13	13	13
Natural gas	Passenger vehicle	13												
	Bus	50												
	Cargo truck	93												
	Special-purpose vehicle	105												

Table 3-39 N_2O emission factors for road transportation [mg-N_2O/km]

Fuel	Vehicle type	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light passenger vehicle	14	14	14	9.3	8.4	7.5	6.7	5.9	5.2	4.6	4.1	3.6	3.2
	Passenger vehicle (including LPG)	24	24	20	12	11	9.4	8.3	7.0	6.1	5.4	4.6	4.0	3.5
	Bus	25												
	Light cargo truck	24	24	22	13	11	10	8.8	8.1	7.5	6.9	6.4	6.0	5.6
	Small cargo truck	21	22	22	13	12	10	9.2	8.4	7.7	7.0	6.4	5.8	5.4
	Regular cargo truck	25												
	Special-purpose vehicle	25												
Diesel	Passenger vehicle	5.7	4.7	4.4	4.4	4.4	4.5	4.6	4.8	4.9	5.1	5.4	5.8	6.2
	Bus	3.0												
	Small cargo truck	9.3	10	11	12	12	12	12	12	12	12	12	12	13
	Regular cargo truck	15	15	15	17	20	23	27	30	32	33	35	36	38
	Special-purpose vehicle	3.0												
Natural gas	Passenger vehicle	0.2												
	Bus	38												
	Cargo truck	13												
	Special-purpose vehicle	15												

- ***Activity Data***

The estimates of annual distance traveled by each vehicle type and by each fuel type are used as activity data. As for gasoline, diesel and LPG vehicles, the method of estimating the distance traveled by each vehicle type and by each fuel type up to FY2009 is to multiply the proportion of distance traveled for each fuel type, which is calculated from fuel consumption and fuel efficiency, by the distance traveled for each vehicle type given in the Ministry of Land, Infrastructure, Transport and Tourism's *Statistical Yearbook of Motor Vehicle Transport*. The annual distance traveled by vehicle type and by fuel type since FY2010 is given in the Ministry of Land, Infrastructure, Transport and Tourism's *Statistical Yearbook of Motor Vehicle Fuel Consumption*. *Monthly Report of Motor Vehicle Transport Statistics* are also used as parameters to estimate the annual distance for some vehicle types.

As for the natural gas vehicle, the annual distance traveled per vehicle type is determined by multiplying the number of natural gas-powered vehicles by the annual distance traveled per vehicle. From FY1990 to FY1996, the number of these vehicles is taken from the number of introduced natural gas-powered vehicles per type in the data compiled by the Japan Gas Association, and from FY1997, the number of registered natural gas-powered vehicles reported in the *Statistics of AIRIA/ Number of Motor Vehicle* compiled by the Automobile Inspection and Registration Information Association (AIRIA). For the annual distance traveled per vehicle, the activity data are calculated using the annual total distance traveled by natural gas-powered vehicles, reported in the *Statistical Yearbook of Motor Vehicle Fuel Consumption*, the annual distance traveled by each vehicle type reported in the *Statistical Yearbook of Motor Vehicle Transport*, and the number of registered vehicle by each vehicle type reported in the *Statistics of AIRIA/ Number of Motor Vehicle*.

Table 3-40 Distance traveled per vehicle type [10^6 vehicle-km]

Fuel	Vehicle type	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light passenger vehicle	15,800	40,725	72,436	106,089	112,417	120,401	125,452	132,957	136,641	137,626	151,305	164,130	180,103
	Passenger vehicle	272,902	304,297	342,901	351,083	345,549	342,654	331,572	334,924	333,244	341,832	354,200	357,816	366,291
	Bus	90	30	20	43	52	65	69	81	314	234	186	167	223
	Light cargo truck	90,707	89,828	79,560	78,333	77,926	77,886	77,803	76,812	75,073	73,130	76,684	80,568	89,963
	Small cargo truck	28,972	20,286	19,582	20,853	21,250	21,217	20,664	20,437	22,228	23,038	23,348	22,810	23,897
	Regular cargo truck	364	294	270	605	719	812	867	891	1,411	1,421	1,515	1,389	1,398
	Special-purpose vehicle	662	693	1,283	1,272	1,317	1,392	1,422	1,503	2,841	2,717	2,779	2,687	2,742
Diesel	Passenger vehicle	39,831	62,934	55,437	29,124	23,374	20,213	16,677	14,028	10,357	9,298	8,537	7,293	7,677
	Bus	6,889	6,619	6,488	6,506	6,501	6,556	6,410	6,372	6,178	6,005	6,027	5,888	5,914
	Small cargo truck	43,649	48,801	45,017	32,816	30,798	29,987	28,599	26,236	23,154	22,500	22,847	21,908	22,241
	Regular cargo truck	57,824	68,143	72,434	69,361	70,298	70,890	68,562	65,292	62,856	60,024	53,082	51,146	48,835
	Special-purpose vehicle	9,173	13,598	17,074	17,108	18,070	18,365	18,082	17,648	20,727	20,341	20,342	19,672	19,199
LPG	Passenger Vehicle	18,000	16,848	15,074	13,692	13,531	13,159	12,607	12,114	12,161	11,245	10,689	10,335	9,506
Natural gas	Passenger vehicle	0.05	0.10	2	6	6	7	7	7	6	5	4	3	2
	Bus	NO	2	15	48	52	55	57	56	52	49	47	39	35
	Cargo truck	0.22	10	79	253	281	298	316	308	303	305	284	266	252
	Special-purpose vehicle	0.05	2	18	57	63	67	71	69	67	66	66	60	57

- ***N_2O emissions from gasoline vehicle in Japan***

With the stipulation of the "1978 Emissions Regulation," the three-way catalyst started to be installed in gasoline automobiles in Japan, leading to an increase in N_2O emissions per distance traveled until around 1986 when the three-way catalyst became widely used. New emission regulations on automobiles were not stipulated until 1997. Therefore, N_2O emissions per distance traveled were stable from 1986 to 1997. From 1997, low emission vehicles were introduced. From 2000, with the stipulation of the "2000 Emission Regulation", N_2O emissions per distance traveled started to decrease in response to the introduction of the Close-coupled Catalytic Converter. Since 1997, the trend of N_2O emissions per distance traveled is on the decrease.

- ***Completeness***

➢ *Methanol*

The number of methanol vehicles owned in Japan was only 12 at the end of March 2013 (data surveyed by AIRIA). Therefore, activity data is negligible, and is not reported, as it is assumed that the emissions are also negligible.

➢ *Lubricants*

Since CH_4 and N_2O emissions from use of lubricants are very small in comparison to CO_2, these can be neglected for the greenhouse gas calculation according to the *2006 IPCC Guidelines* (Vol.3, page 5.7). Therefore the emissions are reported as "NE".

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The emission factors of road transportation vehicle are established from the date provided by JAMA. For the emission factors established from the samples more than five, the uncertainty is calculated from 95% reliable section with the assumption of logarithmic standard deviation. For the emission factors established from the samples less than five, the default values of uncertainty in the *2006 IPCC Guidelines* are adopted. As for the uncertainty of activity data, because the *Statistical Yearbook of Motor Vehicle Fuel Consumption* is used for the activity data, the sample error rate of the motor vehicle fuel consumption survey shown at the Service Statistics and Business Statistics Section Meeting by Cabinet Office, Government of Japan is used for the uncertainty. As a result, the

uncertainty of emissions from road transportation vehicles including motorcycles is evaluated as -36% to +104% for CH_4, and -37% to +107% for N_2O.

- ***Time-series Consistency***

The emission factors are developed by using the same method throughout the time-series. The activity data of gasoline, diesel and LPG vehicles by FY2009 are estimated using the overlap factors given by the Ministry of Land, Infrastructure, Transport and Tourism, to be consistent with the activity data since FY2010. The activity data of natural gas vehicle are estimated based on the number of registered vehicles reported in the *Statistics of AIRIA/ Number of Motor Vehicle* after the accurate data has become available in 1997, and using the Japan Gas Association data for the total number of vehicles introduced before 1996 when the natural gas-powered vehicle was not popular. As for other activity data of natural vehicle, the data are estimated based on the *Statistical Yearbook of Motor Vehicle Transport* and the Statistics of AIRIA by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Hybrid vehicles are considered to the emission estimation of gasoline passenger vehicles. For gasoline light passenger vehicles, gasoline passenger vehicles, diesel passenger vehicles and diesel regular cargo trucks, new measurements of raw emission factors for the vehicles in response to the current regulations for exhaust gas (including vehicles with idle reduction) were provided by JAMA, and emission factors since FY2005 were revised. In addition, in order to ensure the methodological consistency with CO_2, annual distance traveled was revised from the *Statistical Yearbook of Motor Vehicle Transport* basis to the *Statistical Yearbook of Motor Vehicle Fuel Consumption* basis. Therefore, the CH_4 and N_2O emissions for the period of FY1990-FY2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

The emission factors will be reviewed, as appropriate, in order to represent Japan's circumstances more suitably.

3.2.9.2.b. Motorcycles

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from motorcycles.

b) Methodological Issues

- ***Estimation Method***

The CH_4 and N_2O emissions from motorcycles are established by using Tier 3 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 3.14, Fig. 3.2.3). According to the Tier 3 method (Vol. 2, page 3.15, Equation 3.2.5), the equation indicates the aggregation of two types of emissions in different condition, one is the emissions in "hot" condition when the engine is warm, and the other is "cold start" condition when the engine is cold at starting.

In Japan, the emission control regulation for motorcycle has been established in 1999, and JAMA has collected the CH_4 and N_2O emission data measured by test from "hot" and "cold start" condition engines of each type of emission controlled motorcycles. For these motorcycles, the emission factors are established from these measured data, and for emission uncontrolled motorcycles the default values in the *2006 IPCC Guidelines* are used. The CH_4 and N_2O emissions are estimated and aggregated by using the equations below.

CH_4 and N_2O emissions from motorcycles on "hot" condition
= Emission factor for vehicle-km by type of motorcycle and by emission control status
× Total annual distance traveled by motorcycles by type and by emission control status

CH_4 and N_2O missions from motorcycles on "cold start" condition
= Emission factor per startup by type and by emission control status × Number of engine startups per year by each type of motorcycle and by emission control status

- ***Emission Factors***

➢ *Hot*

The CH_4 and N_2O emission factors established by JAMA are used for the emission controlled motorcycles, and for uncontrolled motorcycles the default values in the *2006 IPCC Guidelines* are used.

Table 3-41 CH_4 and N_2O emission factors of motorcycle in "hot" condition [mg/km]

Vehicle type	Emission controlled vehicle[1)]		Emission uncontrolled vehicle [2)]	
	CH_4	N_2O	CH_4	N_2O
Small motor vehicle, type 1	13.3	2.64	53	4
Small motor vehicle, type 2	16.7	0.23		
Light two-wheel vehicle	12.5	0.85		
Small two-wheel vehicle	25.0	1.26		

1) Data provided by JAMA

2) *2006 IPCC Guidelines*, Vol. 2, page 3.22, Table 3.2.3 Motorcycles/Uncontrolled/Running(hot)

➢ *"Cold start" condition*

The CH_4 and N_2O emission factors established by JAMA are used for the emission controlled motorcycles, and for uncontrolled motorcycles the default values in the *2006 IPCC Guidelines* are used.

Table 3-42 CH_4 and N_2O emission factors for motorcycles in "cold start" condition [mg/start]

Vehicle type	Emission controlled vehicle[1)]		Emission uncontrolled vehicle [2)]	
	CH_4	N_2O	CH_4	N_2O
Small motor vehicle, type 1	15.8	11.2	33	15
Small motor vehicle, type 2	18.3	4.2		
Light two-wheel vehicle	30.2	13.7		
Small two-wheel vehicle	27.5	8.1		

1) Data provided by JAMA
2) *2006 IPCC Guidelines*, Vol. 2, page 3.22, Table 3.2.3 Motorcycles/Uncontrolled/cold start

- ***Activity Data***

➢ *Hot*

For the estimation of annual distance traveled by each vehicle type and by each emission control status, firstly and based on the number of owned vehicle by each vehicle type (JAMA), the number of sold vehicle by each sales year and by each vehicle type (JAMA and Japan Light Motor Vehicle and Motorcycle Association) is multiplied by the survival ratio by each past year (*2007 JAMA Trust Research Report; Detailed Examination in Research Method of Number of Owned Light Two-wheel Vehicles* by Japan Automobile Research Institute), and then the ratio of number of owned vehicle of

each year by each past year is obtained, and the number of owned vehicle by each sales year and by each vehicle type is calculated. Secondary, this number is multiplied by annual travel distance by each vehicle type per one vehicle (calculated from *Survey of Motorcycle Market Trends* by JAMA) and multiplied by use factor by each vehicle type and by each past year (*2006 JAMA Trust Research Report; Research in Contribution Rate of the Emissions from Motorcycles* by Japan Automobile Research Institute), then the annual travel distance by each sales year and by each vehicle type is obtained. The emission control status is judged by the sales year.

- *Cold start*

For the estimation of annual number of startup by each vehicle type and by emission control status, the number of owned vehicle by each vehicle type and by each emission control status, which is obtained through the calculation of "hot" activity data, is multiplied by annual number of startup by each vehicle type per one vehicle (calculated from *Survey of Motorcycle Market Trends* by JAMA) and multiplied by use factor by each vehicle type and by each past year (*JAMA Trust Research Report* by Japan Automobile Research Institute), and then the annual number of startup by each sales year and by each vehicle type is obtained. The emission control status is judged by the sales year.

Table 3-43 Activity data of motorcycles

Activity data	Vehicle type	Emission control by regulation	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Distance traveled	Small motor vehicle, type 1	Controlled	10^6 vehicle-km	NO	NO	1,773	4,165	4,348	4,120	3,910	3,919	3,643	3,182	3,092	3,325	3,258
		Uncontrolled		10,623	6,267	3,153	753	529	337	233	169	112	66	42	29	18
	Small motor vehicle, type 2	Controlled		NO	NO	243	1,237	1,412	1,637	1,940	2,013	2,192	2,540	2,695	2,877	3,021
		Uncontrolled		2,060	1,853	1,568	686	544	418	316	238	172	131	91	61	39
	Light two-wheel vehicle	Controlled		NO	NO	565	2,664	3,014	3,174	3,332	3,194	3,127	3,025	3,053	3,141	3,208
		Uncontrolled		6,111	3,577	2,209	1,055	864	682	548	418	330	252	195	147	109
	Small two-wheel vehicle	Controlled		NO	NO	329	1,662	1,915	2,210	2,386	2,637	2,751	2,781	2,952	2,883	3,037
		Uncontrolled		3,568	3,112	2,602	1,292	1,097	949	779	677	559	448	367	271	212
Number of startup	Small motor vehicle, type 1	Controlled	Number of Startup	NO	NO	349	740	772	720	682	673	626	592	574	577	566
		Uncontrolled		1,838	1,131	621	134	94	59	41	29	19	12	8	5	3
	Small motor vehicle, type 2	Controlled		NO	NO	31	140	160	173	204	209	228	245	259	274	288
		Uncontrolled		285	255	203	78	62	44	33	25	18	13	9	6	4
	Light two-wheel vehicle	Controlled		NO	NO	41	177	200	207	217	197	193	195	196	179	183
		Uncontrolled		361	223	159	70	57	45	36	26	20	16	13	8	6
	Small two-wheel vehicle	Controlled		NO	NO	19	77	89	94	106	107	111	111	117	95	87
		Uncontrolled		187	178	154	60	51	40	35	28	23	18	14	9	6

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty of the emissions from motorcycle is included and reported in "3.2.9.2.a Road transportation: vehicles other than motorcycles". Therefore, please refer to the description in the uncertainties of the section.

- ***Time-series Consistency***

The same estimation factors are used throughout the time-series. As for the activity data, the number of owned vehicle, travel distance per one vehicle, and number of startup per one vehicle are estimated using the data provided by JAMA, Japan Light Motor Vehicle and Motorcycle Association, and Ministry of the Environment by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The CH_4 and N_2O emissions from FY1999 to FY2013 were recalculated due to an update of emission factors for light two-wheel vehicles in response to the regulations for exhaust gas. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.9.3. Railways (1.A.3.c.)

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from railways. Emissions from railways come mainly from diesel-engine railway cars. In addition, there are small amounts of emissions from coal-fired steam locomotives.

b) Methodological Issues

- ***Estimation Method***

The emissions are calculated by using Tier 1 method in accordance with the *2006 IPCC Guidelines* (Vol. 2, page 3.41, Fig. 3.4.2).

CH_4 and N_2O emissions from diesel engines in railways = Emission factor for diesel engines in railways × Annual consumption of diesel oil for diesel engines in railways

CH_4 and N_2O emissions from steam locomotives = Emission factor for coal in rail transportation × Annual consumption of coal for steam locomotives

- ***Emission Factors***

For emission factors for diesel-powered railway cars, the default values of "Diesel" shown in the *2006 IPCC Guidelines* are used after conversion to a per-liter value using the calorific value of diesel oil.

For the emission factors for steam locomotives, the default values of "sub-bituminous coal" shown in the *2006 IPCC Guidelines* are used after conversion to a per-weight value using the calorific value of imported steam coal.

Table 3-44 Default values for railway emission factors

Gas	Diesel engines	Steam locomotives
CH_4	4.15 [kg-CH_4/TJ]	2 [kg-CH_4/TJ]
N_2O	28.6 [kg-N_2O/TJ]	1.5 [kg-N_2O/TJ]

Source: *2006 IPCC Guidelines*, Vol. 2, p. 3.43, Table 3.4.1
These emission factors indicate the emissions per NCV.

- ***Activity Data***

For the consumption of diesel oil by diesel engines in railways and coal consumption by steam locomotives, the diesel oil and coal consumption in the railway shown in the *General Energy Statistics* compiled by the Agency for National Resources and Energy is used as activity data, respectively.

Table 3-45 Activity data used for estimation of emissions from railways

Fuel type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Diesel oil	1000 kl	356	313	270	248	238	227	230	225	218	211	211	205	205
Coal	kt	1.3	1.2	1.7	1.4	1.3	1.3	1.5	1.7	1.7	1.7	1.6	1.5	1.5

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

Since the default values in the *2006 IPCC Guidelines* are adopted for the emission factors of railways, the uncertainties indicated in the *2006 IPCC guidelines* (-60% to +151% for CH_4 and -50% to +200% for N_2O) are adopted. Also, since the values in the *General Energy Statistics* are used for the activity data, the default values in the *2006 IPCC Guidelines* (-5% to +5%) are adopted for the uncertainty of activity data. As a result, the uncertainty of the emissions from railways is evaluated as -60% to +151% for CH_4 and -50% to +200% for N_2O.

- ***Time-series Consistency***

The same emission factors are used throughout the time-series. The data given in the *General Energy Statistics* are used as activity data consistently throughout the time-series.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The emissions from FY1990 to FY2013 were recalculated due to a revison of calorific values. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.9.4. Domestic Navigation (1.A.3.d.)

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from domestic navigation of ships for passenger and freight transport.

b) Methodological Issues

- ***Estimation Method***

The emissions were calculated by using Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 3.49, Fig. 3.5.1).

CH_4 and N_2O emissions associated with the navigation of domestic vessels = Emission factors for diesel oil and fuel oils A, B and C relating to domestic vessels × Consumption of each type fuel by domestic vessels

- ***Emission Factors***

The default values for Ocean-Going Ships (diesel engines) given in the *2006 IPCC Guidelines* (see the following table) are converted to emission factors per liter using the calorific value for each type of fuel (diesel oil, fuel oil A, B and C).

Table 3-46 Default emission factors for navigation

Gas	Emission factor
CH_4	7 [kg-CH_4/TJ]
N_2O	2 [kg-N_2O/TJ]

Source: *2006 IPCC Guidelines* Vol. 2, page 3.50, Table 3.5.3
These emission factors indicate the emissions per NCV.

- ***Activity Data***

The consumption of each fuel type in the domestic navigation taken from the *General Energy Statistics* of the Agency for Natural Resources and Energy is used for activity data.

Table 3-47 Activity data used for estimation of emissions from ships [1000 kl]

Fuel type	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Diesel oil	133	208	204	195	172	189	189	163	154	149	141	142	142
Fuel oil A	1,602	1,625	1,728	1,324	1,224	1,126	1,046	946	1,007	969	1,006	994	987
Fuel oil B	526	215	152	63	41	42	25	20	18	16	16	14	12
Fuel oil C	2,446	3,002	3,055	2,873	2,889	2,792	2,592	2,420	2,482	2,460	2,517	2,487	2,507

- ***Completeness***

According to the *2006 IPCC Guidelines* (Vol. 3, page 5.7), CH_4 and N_2O emissions from use of lubricants are very small in comparison to CO_2, and these can be neglected for the greenhouse gas calculation. Therefore, the estimation is not done.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

Since the default values in the *2006 IPCC Guidelines* are adopted for the emission factors of domestic navigation, the uncertainties indicated in the *2006 IPCC guidelines* (-50% to +50% for CH_4 and -40% to +140% for N_2O) are adopted. Also, since the values in the *General Energy Statistics* are used for the activity data, the default values in the *2006 IPCC Guidelines* (-13% to +13%) are adopted for the uncertainty of activity data. As a result, the uncertainty of the emissions from domestic navigation is evaluated as -52% to +52% for CH_4 and -42% to +141% for N_2O.

- ***Time-series Consistency***

The same values for emission factors are throughout the time-series. The values given in the *General Energy Statistics* are used as activity data for domestic navigation consistently throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The emissions from FY1990 to FY2013 were recalculated due to a revision of calorific values. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.9.5. Other Transportation (1.A.3.e.)

This subcategory is reported as "NO", since fossil fuels are not combusted to transport materials by pipelines and no other activities to be reported are found.

3.2.10. CO_2 Emissions from Other Sectors (1.A.4.: CO_2)

a) Category Description

This category provides the estimation methods for CO_2 emissions from the commercial/institutional (1.A.4.a), residential (1.A.4.b) and agriculture/forestry/fishing (1.A.4.c) sectors.

In FY2014, CO_2 emissions from this category accounted for 137,258 kt-CO_2, and represented 10.1% of Japan's total GHG emissions (excluding LULUCF). The commercial/institutional (1.A.4.a) accounts for 57.9%, and is the largest subcategory within the "Other sectors" category in FY2014.

CO_2 emissions from this category change due to activity level of commercial/institutional, number of households, temperature and so on. The CO_2 emissions from commercial/institutional (1.A.4.a), which is the largest source in Other sectors, are considered to have a moderate correlation with the *Indices of Tertiary Industry Activity* (ITA; the Ministry of Economy, Trade and Industry), which are one of indicators to show activity level of commercial/institutional. The CO_2 emissions have decreased since 2005 due to the decrease in the demand of liquid fuels.

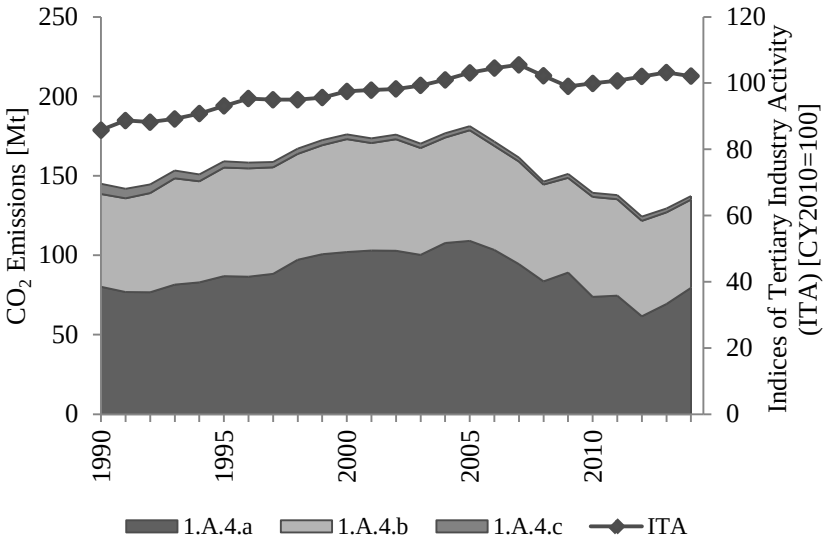


Figure 3-9 The trends of CO_2 emissions from Other Sectors (1.A.4) and related indicator

b) Methodological Issues

- ***Estimation Method***

The Tier 2 Sectoral Approach has been used in accordance with the decision tree of the *2006 IPCC Guidelines* to calculate emissions (Vol.2, Page 1.9, Fig. 1.2), as was the case for the energy industries (1.A.1). See 3.2.4. b).

The CO_2 emissions from biomass are not included in the national totals but are reported in the CRFs as reference in accordance with the *2006 IPCC Guidelines*.

- ***Emission Factors***

The emission factors elaborated in the energy industries (1.A.1) were also used in this category. See 3.2.4. b).

- ***Activity Data***

The data given in the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy were used for activity data, as was the case for the energy industries (1.A.1).

The activity data for each sub-category were calculated by totaling the final energy consumption in the commercial industry (#650000), residential (#700000), and agriculture, forestry and fishery (#611000) sectors, energy consumption related to non-utility power generation for use in one's own offices (auto power generation: #25xxxx), and energy consumption related to steam production for use in own offices (auto steam generation: #26xxxx) shown in the *General Energy Statistics*. Because the final energy consumption above includes the amount of non-energy use which was used for purposes other than combustion (non-energy and feedstock use: #951100 and #952000), these values were deducted from the energy consumption in each category.

The energy consumption of each fuel in the agriculture, forestry and fishery (#611000) sector in the *General Energy Statistics* is classified to mobile combustion and stationary combustion according to the ratio in the Table 3-50, which is the survey results by the Ministry of the Environment in FY2014 and FY2015. Please refer to the Table 3-49 for which category the emissions from mobile or stationary combustion to be allocated in the CRF table.

The auto power generation and auto steam generation sectors are included in the energy transformation & own use sector in *General Energy Statistics*. However, the *2006 IPCC Guidelines* allocates CO_2 emissions from energy consumption for power or steam generation to the sectors generating that power or steam. As such, these CO_2 emissions are added to those from each office in the final energy consumption sector and are reported in 1.A.4.

Table 3-48 Energy consumptions in Other Sectors (1.A.4) (unit: PJ)

Fuel	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Liquid fuels	1,730	1,906	2,049	2,077	1,942	1,728	1,563	1,628	1,493	1,472	1,277	1,305	1,264
Solid fuels	53	26	31	18	18	17	18	26	10	20	13	23	60
Gaseous fuels	452	556	690	782	781	864	788	774	751	732	751	768	905
Other fossil fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Biomass	4.4	3.2	2.0	1.0	1.0	0.9	1.0	0.9	73	70	66	73	75
Total	2,239	2,492	2,773	2,877	2,742	2,611	2,370	2,429	2,327	2,294	2,108	2,169	2,304

Table 3-49 Correspondence between sectors of Japan's Energy Balance Table and those of the CRF (1.A.4)

CRF			General Energy Statistics	
1A4	Other sectors			
	1A4a Commercial/institutional		Auto power generation (except for Agriculture, fishery, mining and construction [#251000] and Manufacturing [#252000])	#255000
			Auto steam generation (except for Agriculture, fishery, mining and construction [#261000] and Manufacturing [#262000])	#265000
			Final energy consumption; Commercial industry	#650000
			Non-energy and feedstock use; Commercial	#951800
	1A4b Residential		Final energy consumption; Residential	#700000
			Non-energy and feedstock use; Household	#952000
	1A4c Agriculture/forestry/fishing			
		i Stationary	Auto power generation; Agriculture, fishery, mining and construction	#251000
			Auto steam generation; Agriculture, fishery, mining and construction	#261000
			Final energy consumption; Agriculture, forestry and fishery [#610000]; stationary sources (estimates)	
			Non-energy and feedstock use; Agriculture, fishery, mining and construction	#951100
		ii Off-road vehicles and other machinery	Final energy consumption; Agriculture [#611100]; mobile sources (estimates)	
			Final energy consumption; Forestry [#611200]; mobile sources (estimates)	
		iii Fishing	Final energy consumption; Fishery, except aquaculture [#611300]; mobile sources (estimates)	
			Final energy consumption; Aquaculture [#611400]; mobile sources (estimates)	

#95xxxx items are subtracted as non-energy use activities.

Table 3-50 Ratio of mobile and stationary combustion by fuel in the agriculture/forestry/fishing (1.A.4.c)

Fuel	Agriculture		Forestry		Aquaculture			Fishery, except Aquaculture		
	Mobile com-bustion	Station-ary com-bustion	Mobile com-bustion	Station-ary com-bustion	Mobile com-bustion (ships)	Mobile com-bustion	Station-ary com-bustion	Mobile com-bustion (ships)	Mobile com-bustion	Station-ary com-bustion
Diesel oil	99%	1%	100%	0%	0%	100%	0%	0%	100%	0%
Fuel oil A	5%	95%	0%	100%	100%	0%	0%	100%	0%	0%
Kerosene	2%	98%	0%	100%	0%	0%	100%	0%	0%	100%
LPG and town gas	5%	95%	0%	100%	0%	0%	100%	0%	0%	100%

Source: *Actual condition survey of GHG emissions from non-manufacturing industry, Fiscal year 2014* (Ministry of the Environment)

c) Uncertainties and Time-series Consistency

See 3.2.4. c).

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

The CO_2 emissions in FY2012 and 2013 were recalculated with a revision of the carbon emission factors and the fuel consumption of the *General Energy Statistics*. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.11. CH_4 and N_2O Emissions from Other Sectors (1.A.4.:CH_4 and N_2O)

a) Category Description

This category provides the estimation methods for CH_4 and N_2O emissions from the commercial/institutional (1.A.4.a), residential (1.A.4.b) and agriculture/forestry/fishing (1.A.4.c) sectors.

This category also provides the estimation methods for determining CH_4 and N_2O emissions from mobile combustion such as off-road vehicles, fishing boats and other machinery.

b) Methodological Issues

- ***Estimation Method***

➢ *Furnaces*

For Commercial/institutional (1.A.4.a) and the stationary combustion in Agriculture/forestry/fishing (1.A.4.c), same with Energy Industries (1.A.1), CH_4 and N_2O emissions from fuel combustion in this category are calculated by using Tier 3 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol.2, Page 1.9, Fig. 1.2). See 3.2.5. b) (1.A.1).

➢ *Residential*

For Residential (1.A.4.b), CH_4 and N_2O emissions from fuel combustion in this category are calculated by using Tier 1 method, since furnace-specific activity data is not available.

➢ *Off-road vehicles and other machinery*

The emissions from mobile combustion in Agriculture/forestry/fishing (1.A.4.c) are estimated by Tier 1 in accordance with the decision tree of the *2006 IPCC Guidelines* to calculate emissions (Vol.2, Page 3.34, Fig. 3.3.1).

- ***Emission Factors***

➢ *Furnaces*

For Commercial/institutional (1.A.4.a) and the stationary combustion in Agriculture/forestry/fishing (1.A.4.c), the emission factors which were established in Energy Industries (1.A.1) were used. See Table 3-20 and Table 3-21 (1.A.1).

➢ *Residential*

For Residential (1.A.4.b), the emission factors which were provided in the *2006 IPCC guidelines* (Vol. 3, pages 2.22-2.23, Table 2.5) were used.

Table 3-51 CH_4 emission factors for residential (1.A.4.b) (Unit: kg-CH_4/TJ)

Furnace type	Fuel type	Emission factor	Remarks
Household equipment	Liquid fuel	9.5	IPCC default value converted to the higher heating value
	Solid fuel	290	
	Gaseous fuel	4.5	
	Biomass fuel	290	

Table 3-52 N_2O emission factors for residential (1.A.4.b) (Unit: kg-N_2O/TJ)

Furnace type	Fuel type	Emission factor	Remarks
Household equipment	Liquid fuel	0.57	IPCC default value converted to the higher heating value
	Solid fuel	1.3	
	Gaseous fuel	0.090	
	Biomass fuel	3.8	

➢ *Off-road vehicles and other machinery*

The emission factors of diesel oil used for the mobile combustion in agriculture, fishing and aquaculture were estimated from the values of "1.A.2.f.ii and 1.A.4.a.ii/ Diesel" in the Table 3-1 of *EMEP/EEA air pollutant emission inventory guidebook 2013*. The emission factors of fuel oil A and kerosene used for agriculture were not shown in the guidebook but were applied the same value of diesel oil since most of the fuel oil A and kerosene are also used for tractors. The emission factors of LPG and town gas were estimated from the value of "LPG" in the same Table, and the emission factors of diesel oil for forestry were estimated from the values of "1.A.4.c.ii-Forestry/ Diesel" in the same Table.

The emission factors of fuel oil A used for fishing and aquaculture were estimated from the values on Table 3.5.3 "Default water-borne navigation CH_4 and N_2O emission factors" in the *2006 IPCC Guidelines* vol. 2, page3.50.

Table 3-53 Emission factors of CH_4 and N_2O for off-road vehicles and other machinery in agriculture/forestry/fishing (1.A.4.c) (Unit: kg/TJ)

Fuel	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	References
Diesel oil, Kerosene, Fuel oil A used for other than ships	kgCH_4/TJ	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	EMEP/EEA air pollutant emission inventory guidebook 2013 Table 3-1
	kgN_2O/TJ	3.0	3.0	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
Diesel oil for forestry	kgCH_4/TJ	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
	kgN_2O/TJ	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	
LPG, Town gas	kgCH_4/TJ	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.1	7.1	
	kgN_2O/TJ	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	
Fuel oil A for ships	kgCH_4/TJ	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	2006 IPCC Guidelines Table 3.5.3
	kgN_2O/TJ	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	

● ***Activity Data***

➢ *Furnaces*

The fuel consumption, obtained by multipling the fuel consumption of each sector and each fuel type in the *General Energy Statistics* by the ratio of stationary combustion in the Table 3-50 and the fuel consumption ratio by furnace type, is assumed to be the activity data for the stationary combustion namely combustion in furnaces. Same with Energy Industries (1.A.1), the fuel consumption ratios by furnace were estimated from data by furnace on the *General Survey of the Emissions of Air Pollutants* and data on each fuel consumption statistics (the *Yearbook of the Current Survey of Energy Consumption*, energy consumption statistics, electric power statistics, and gas business production dynamic statistics). See 3.2.5. b) (1.A.1).

➢ *Residential*

The fuel consumption by fuel type in the *General Energy Statistics* was used for the activity data of residential (1.A.4.b).

➢ *Off-road vehicles and other machinery*

The fuel consumption, estimated by multipling the fuel consumption of each fuel type in Agriculture, Forestry and Fishery in the *General Energy Statistics* by the ratios of fuel consumption of mobile

combustion (Table 3-50), were used for the activity data of mobile combustion namely off-road vehicles and other machinery.

c) Uncertainties and Time-series Consistency

See 3.2.5. c).

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

CH_4 and N_2O emissions in FY2012 and 2013 were recalculated with a revision of the fuel consumption for FY2012 and 2013 in the *General Energy Statistics.*

CH_4 and N_2O emissions in FY1990-2013 were recalculated with an establishment of the estimation method of the emissions from the mobile combustion such as machinery for forestry and fishing boats in the forestry, aquaculture and fishery sectors.

See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.12. Emission from waste incineration with energy recovery

The three cases below in which waste is utilized as crude material meet the definition of emissions from waste incineration with energy recovery.

- Waste incineration with energy recovery
- Direct use of waste as fuel
- Use of waste processed as fuel

The estimation method for emissions from these sources is applied for waste incineration (5.C) in accordance with the *2006 IPCC Guidelines*. The value of emissions is included in fuel combustion (1.A.1 and 1.A.2) in accordance with the *2006 IPCC Guidelines.* Please refer to Chapter 7 for the details of the estimation methods.

The reporting category of the emissions for each type of waste is either “energy industries (category 1.A.1)” or “manufacturing industries and construction (1.A.2)” according to the use of waste as fuel or raw material. The fuel type is classified as “other fossil fuels” and “biomass”.

Greenhouse gas emissions during the direct use of waste as a raw material, such as plastics used as reducing agents in blast furnaces or as a chemical material in coking furnaces, or the use of intermediate products manufactured using the waste as a raw material, are estimated in this category.

Refuse-derived solid fuels (RDF: Refuse-Derived Fuel, RPF: Refuse Paper and Plastic Fuel) are used for the estimation of emissions from fuels produced from waste. The reporting categories of the above emissions are included in “energy industries (category 1.A.1)” or “manufacturing industries and

construction (1.A.2)" according to the use of waste as fuels. The fuel type is classified as "other fossil fuels" and "biomass".

Table 3-54 Waste types whose emissions are estimated for waste incineration and energy use (reported on energy sector: 1.A.)

Category	Waste type			Fuel type to be allocated to CRF	Treatment type		CO_2	CH_4	N_2O
1.A.1. (7.4.3.1)[7]	Municipal solid waste	Plastics	Fossil-fuel derived plastics	Other fossil fuels	Incineration with energy recovery	* Incinerator -continuous, -semi-continuous -batch type * Gasification melting furnace	○	○[2]	○[2]
			Biomass-based plastics	Biomass			NA[1]		
		Paper/ cardboard	Fossil-fuel derived fraction	Other fossil fuels			○		
			Biogenic fraction	Biomass			NA[1]		
		Nappy (Fossil-fuel derived fraction)		Other fossil fuels			○		
		Textiles	Synthetic textile	Other fossil fuels			○		
			Natural fiber	Biomass			NA[1]		
		Other (biogenic)		Biomass			NA[1]		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil	Other fossil fuels		Incinerator	○	○	○
			Animal and vegetable oil	Biomass			NA[1]	○	○
		Plastics	Fossil-fuel derived plastics	Other fossil fuels			○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
		Food waste [Animal and vegetable residues/animal carcasses]		Biomass			NA[1]	○	○
		Paper/ cardboard	Fossil-fuel derived fraction	Other fossil fuels			○	IE[4]	IE[4]
			Biogenic fraction	Biomass			NA[1]	○	○
		Wood		Biomass			NA[1]	○	○
		Textile	Synthetic textile	-			IE[5]	IE[5]	IE[5]
			Natural fiber	Biomass			NA[1]	○	○
		Sludge	Sewage sludge	-			NO	NO	NO
			Other than sewage sludge	Biomass			NA[1]	○	○
	Specially controlled industrial waste			-			IE[6]	IE[6]	IE[6]
1.A.1/2 (7.4.3.2)[7]	Municipal solid waste	Plastics	Fossil-fuel derived plastics	Other fossil fuels		Direct use as alternative fuel	○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
	Industrial solid waste	Waste oil	Fossil-fuel derived oil	Other fossil fuels			○	○	○
			Animal and vegetable oil	Biomass			NA[1]	○	○
		Plastics	Fossil-fuel derived plastics	Other fossil fuels			○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
		Wood		Biomass			NA[1]	○	○
	Waste tire		Fossil-fuel derived fraction	Other fossil fuels			○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]
1.A.1/2 (7.4.3.3)[7]	Refuse Derived Fuel (RDF)		Fossil-fuel derived fraction	Other fossil fuels		Incineration of waste processed as fuel	○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]
	Refuse Paper and Plastic Fuel (RPF)		Fossil-fuel derived fraction	Other fossil fuels			○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]

1) CO_2 emissions from the incineration of biomass-derived waste are not included in the total emissions; instead it is estimated as a reference value and reported as "Biomass" fuel in the CRF tables.
2) CH_4 and N_2O emissions from incineration of municipal solid waste in bulk are estimated by each incineration type and reported as "Other fossil fuels" in the CRF tables.
3) Included in fossil-fuel derived plastics in ISW
4) Included in biogenic fraction of paper/cardboard
5) Included in "Specially controlled industrial waste" incineration without energy recovery
6) Included in the fossil-fuel derived fraction
7) For details of categories to be reported in the CRF, see descriptions on each section.

Table 3-55 Reporting categories on the energy sector whose emissions are estimated for waste incineration and energy use

Treatment type	Waste type		Application breakdown	Major application	Reporting category on the energy sector	CO_2 [3]	CH_4	N_2O
Waste incineration with energy recovery	MSW		-	Waste incineration with energy recovery	1.A.1.a. Public electricity and heat production	○	○	○
	ISW					○	○	○
Direct use of waste as alternative fuel	MSW Plastics		Petrochemical	Fuel	1.A.2.g. Other	○	○	○
			Blast furnace reducing agent	Reducing agent in blast furnace	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Coke oven chemical feedstock	Alternative fuel or raw material in coke oven	1.A.1.c. Manufacture of solid fuels	○	IE[5]	NO[6]
			Gasification	Fuel	1.A.2.g. Other	○	NE[7]	NE[7]
	Industrial waste	Waste oil	Other	Fuel	1.A.2.g. Other	○	○	○
		Plastics	Blast furnace reducing agent	Blast furnace reducing agent	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Boiler	Fuel	1.A.2.c. Chemicals	○	○	○
			Boiler	Fuel	1.A.2.d. Pulp, paper and print	○	○	○
			Cement burning	Cement burning	1.A.2.g. Other	○	○	○
			Boiler	Fuel	1.A.2.g. Other	○	○	○
		Wood	-	Fuel	1.A.2.g. Other	NA	○	○
	Waste tire		Cement burning	Cement burning	1.A.2.g. Other	○	○	○
			Boiler	Fuel	1.A.2.g. Other	○	○	○
			Iron manufacture	Alternative fuel or raw materials in iron manufacturing	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Gasification	Fuel in iron manufacturing	1.A.2.a. Iron & Steel	○	○	○
			Metal refining	Fuel in metal refining	1.A.2.b. Non-ferrous metals	○	○	○
			Tire manufacture	Fuel in tire manufacturing	1.A.2.c. Chemicals	○	○	○
			Paper manufacture	Fuel in paper manufacturing	1.A.2.d. Pulp, paper and print	○	○	○
			Power generation	Power generation	1.A.1.a. Electricity generation[1]	○	○	○
Incineration of waste processed as fuel	Refuse-derived fuel (RDF)		-	Fuel use (including power generation)	1.A.2.g. Other [2]	○	○	○
	Refuse-derived fuel (RPF)		Petroleum product manufacturer	boiler fuel	1.A.1.b. Petroleum refining	○	○	○
			Chemical industry	boiler fuel	1.A.2.b. Chemicals	○	○	○
			Paper industry	Fuel use in paper manufacturing	1.A.2.d. Pulp, paper and print	○	○	○
			Cement manufacturer	Cement burning	1.A.2.g. Other	○	○	○

1) Since the industry category for the use of it is not identified, "1.A.1.a." is applied.
2) Emissions from power generation and heat supply excluding in-house use should be included in the category 1.A.1.a. However, they are reported in the category 1.A.2.g., because the actual circumstances are not understood at the moment.
3) CO_2 emissions from the incineration of biomass-derived fraction are not included in the total emissions; instead it is estimated as a reference value and reported as "Biomass" fuel in the CRF tables. For detail, see Table 3-54.
4) Blast furnace gas generated from steel industry is entirely recovered.
5) These emissions are included in "solid fuels" in the same category 1.A.1.c.
6) N_2O is likely not produced since the atmosphere in coke oven is normally at least 1,000 degree Celsius, and reducing.
7) Considering that small fraction of these sources is combusted as alternative fuel but these are mostly used to obtain feedstock for ammonia productions, the emissions are not estimated.

The greenhouse gas emissions from waste incineration for energy purpose and with energy recovery are shown in Table 3-56.

Table 3-56 GHG emissions from waste incineration with energy recovery and use of waste as raw material or fuel

Item		Unit	1990	1995	2000	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1.A.1. Energy industries	a. Public electricity and heat production	kt-CO_2	6,679	7,292	9,330	9,347	8,241	7,137	7,134	7,605	6,633	6,201	6,290	7,180	7,081	6,798
	b. Petroleum refining	kt-CO_2	NO	NO	0.62	8.3	6.4	10.0	5.3	3.5	4.6	5.8	4.6	5.5	4.5	5.0
	c. Manufacture of solid fuels and other energy industries	kt-CO_2	NO	NO	15	191	241	214	196	194	205	242	232	235	NO	25
1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-CO_2	NO	NO	310	672	637	502	510	379	446	547	487	537	417	577
	b. Non-ferrous metals	kt-CO_2	119	63	51	18	17	13	13	3.3	1.7	1.7	1.7	NO	NO	NO
	c. Chemicals	kt-CO_2	14	64	89	77	67	69	63	66	67	73	72	83	80	64
	d. Pulp, paper and print	kt-CO_2	NO	56	114	627	998	1,350	1,606	1,614	1,662	1,726	1,747	1,772	1,853	1,906
	e. Food processing, beverages and tobacco	kt-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	f. Non-metallic minerals	kt-CO_2	197	492	879	1,091	1,088	1,226	1,301	1,374	1,391	1,324	1,355	1,358	1,455	1,638
	g. Other	kt-CO_2	3,841	4,431	4,386	5,436	5,695	5,516	5,888	5,147	4,880	5,121	5,113	5,215	4,986	4,839
Total		kt-CO_2	10,849	12,398	15,175	17,468	16,989	16,037	16,717	16,386	15,292	15,241	15,301	16,385	15,877	15,851
1.A.1. Energy industries	a. Public electricity and heat production	kt-CH_4	0.54	0.54	0.60	0.15	0.15	0.15	0.15	0.15	0.13	0.13	0.13	0.14	0.13	0.13
	b. Petroleum refining	kt-CH_4	NO	NO	1.7.E-06	2.3.E-05	1.8.E-05	2.8.E-05	1.5.E-05	9.8.E-06	1.3.E-05	1.6.E-05	1.3.E-05	1.5.E-05	1.3.E-05	1.4.E-05
	c. Manufacture of solid fuels and other energy industries	kt-CH_4	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	NO	IE
1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-CH_4	NO	NO	NO	6.8.E-05	3.6.E-04	4.6.E-04	5.7.E-04	6.5.E-04	6.5.E-04	6.6.E-04	6.1.E-04	6.1.E-04	5.9.E-04	6.7.E-04
	b. Non-ferrous metals	kt-CH_4	3.2.E-04	1.8.E-04	1.4.E-04	5.3.E-05	7.7.E-05	6.1.E-05	6.1.E-05	1.5.E-05	7.7.E-06	7.7.E-06	7.7.E-06	NO	NO	NO
	c. Chemicals	kt-CH_4	6.2.E-05	1.3.E-04	1.9.E-04	1.8.E-04	1.9.E-04	2.0.E-04	1.7.E-04	1.9.E-04	1.9.E-04	2.0.E-04	2.0.E-04	2.3.E-04	2.2.E-04	1.7.E-04
	d. Pulp, paper and print	kt-CH_4	NO	1.0.E-04	2.4.E-04	1.5.E-03	2.7.E-03	3.7.E-03	4.4.E-03	4.5.E-03	4.6.E-03	4.8.E-03	4.8.E-03	4.9.E-03	5.1.E-03	5.3.E-03
	e. Food processing, beverages and tobacco	kt-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	f. Non-metallic minerals	kt-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	g. Other	kt-CH_4	1.8	1.9	2.4	2.9	3.1	3.3	3.5	4.3	4.5	4.4	4.6	4.7	5.0	5.2
Total		kt-CH_4	2.3	2.4	3.0	3.1	3.3	3.4	3.7	4.4	4.6	4.6	4.7	4.8	5.2	5.3
		kt-CO_2 eq.	59	60	74	77	81	86	92	110	115	114	119	121	129	133
1.A.1. Energy industries	a. Public electricity and heat production	kt-N_2O	1.2	1.3	1.6	1.2	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	0.96	0.93
	b. Petroleum refining	kt-N_2O	NO	NO	1.1.E-05	1.5.E-04	1.2.E-04	1.8.E-04	9.5.E-05	6.3.E-05	8.3.E-05	1.0.E-04	8.3.E-05	1.0.E-04	8.1.E-05	9.0.E-05
	c. Manufacture of solid fuels and other energy industries	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1.A.2. Manufacturing industries and construction	a. Iron and steel	kt-N_2O	NO	NO	NO	1.3.E-04	7.0.E-04	8.9.E-04	1.1.E-03	1.3.E-03	1.3.E-03	1.3.E-03	1.2.E-03	1.2.E-03	1.1.E-03	1.3.E-03
	b. Non-ferrous metals	kt-N_2O	2.4.E-04	1.3.E-04	1.1.E-04	3.9.E-05	5.6.E-05	4.5.E-05	4.5.E-05	1.1.E-05	5.6.E-06	5.6.E-06	5.6.E-06	NO	NO	NO
	c. Chemicals	kt-N_2O	4.4.E-05	6.0.E-04	9.2.E-04	8.6.E-04	1.1.E-03	1.1.E-03	1.1.E-03	1.1.E-03	1.1.E-03	1.2.E-03	1.2.E-03	1.4.E-03	1.4.E-03	1.1.E-03
	d. Pulp, paper and print	kt-N_2O	NO	6.6.E-04	1.4.E-03	9.6.E-03	1.7.E-02	2.4.E-02	2.8.E-02	2.8.E-02	2.9.E-02	3.0.E-02	3.0.E-02	3.1.E-02	3.2.E-02	3.3.E-02
	e. Food processing, beverages and tobacco	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	f. Non-metallic minerals	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	g. Other	kt-N_2O	0.036	0.042	0.053	0.066	0.072	0.075	0.079	0.086	0.087	0.087	0.089	0.090	0.094	0.097
Total		kt-N_2O	1.2	1.4	1.6	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
		kt-CO_2 eq.	371	414	487	382	378	374	357	358	330	325	320	339	325	316

1) Include fossil-fuel derived component only.
CO_2 emissions from the incineration of biomass-derived waste (including biomass-based plastics and waste animal and vegetable oil) is not included in the total emissions in accordance with the *2006 IPCC Guidelines*; instead it is estimated as a reference value and reported under “Biomass” in CRF table 1.A(a).
2) Include both fossil-fuel derived component and biogenic component.

3.3. Fugitive Emissions from Fuels (1.B.)

The Fugitive Emissions subsector consists of intentional and unintentional GHG emissions from unburned fossil fuels during their mining, production, processing, refining, transportation, storage, and distribution, and from geothermal power plants.

There are two main source categories in this sector: solid fuels (1.B.1): emissions from coal mining and handling, and oil and natural gas (1.B.2): emissions from the oil and natural gas industries. The main source of emissions from solid fuels is CH_4 contained in coal bed, whereas fugitive emissions, venting, flaring, volatilization, and accidents are the main emission sources in the oil and natural gas industries. The emissions from geothermal power generation are also reported in 1.B.2.d.

In FY2014, GHG emissions from fugitive emissions from fuels were 1,233 kt-CO_2 eq. and accounted for 0.09 % of Japan's total GHG emissions (excluding LULUCF). The emissions have decreased by 76 % compared to 1990.

Table 3-57 Emission trends of the fugitive emissions subsector (1.B)

Gas	CRF Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	1.B.1 Solid Fuels	a. Coal Mining	kt-CH_4	187.9	93.3	60.5	24.8	24.5	23.2	22.5	22.1	21.5	21.2	20.9	20.4	20.7
		b. Solid Fuel Transformation		2.5	2.5	2.0	1.3	1.3	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.9
		c. Other (Uncontrolled Combustion and Burnig Coal Dump)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	1.B.2 Oil and Natural Gas	a. Oil		1.0	1.1	1.1	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	0.9	0.9
		b. Natural Gas		7.0	7.8	8.8	10.7	11.4	12.6	12.3	11.8	11.1	10.9	10.5	9.8	9.2
		c. Venting and Flaring		0.3	0.5	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
		d. Other (Geothermal Genaration)		0.2	0.8	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4
	Total		kt-CH_4	198.9	105.9	73.4	39.1	39.3	39.0	37.9	36.7	35.4	34.7	34.0	32.7	32.3
			kt-CO_2 eq.	4,973	2,647	1,836	976	982	975	947	916	885	867	851	816	807
CO_2	1.B.1 Solid Fuels	a. Coal Mining	kt-CO_2	5.3	2.4	1.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
		b. Solid Fuel Transformation		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		c. Other (Uncontrolled Combustion and Burnig Coal Dump)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	1.B.2 Oil and Natural Gas	a. Oil		0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
		b. Natural Gas		0.6	0.7	0.8	1.0	1.1	1.2	1.2	1.1	1.0	1.0	1.0	0.9	0.9
		c. Venting and Flaring		81.2	109.1	122.6	164.3	196.0	274.2	273.9	258.2	221.7	224.0	232.2	221.6	209.8
		d. Other (Geothermal Genaration)		104.4	409.2	386.6	341.9	355.4	339.7	289.5	241.0	251.2	251.9	256.5	215.1	215.1
	Total		kt-CO_2	192	521	512	508	553	616	565	501	475	477	490	438	426
N_2O	1.B.1 Solid Fuels	a. Coal Mining	kt-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		b. Solid Fuel Transformation		NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
		c. Other (Uncontrolled Combustion and Burnig Coal Dump)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	1.B.2 Oil and Natural Gas	a. Oil		IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
		b. Natural Gas														
		c. Venting and Flaring		0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003
		d. Other (Geothermal Genaration)		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-N_2O	0.0004	0.0005	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003
			kt-CO_2 eq.	0.11	0.15	0.11	0.11	0.11	0.11	0.12	0.11	0.10	0.10	0.10	0.09	0.09
Total of all gases			kt-CO_2 eq.	5,165	3,169	2,347	1,484	1,536	1,591	1,512	1,417	1,360	1,345	1,341	1,255	1,233

3.3.1. Solid Fuels (1.B.1.)

3.3.1.1. Coal Mining and Handling (1.B.1.a.)

3.3.1.1.a. Underground Mines (1.B.1.a.i.)

a) Category Description

This source category provides the estimation methods for CH_4 and CO_2 emissions from coal mining, post-mining process, and abandoned mines.

Coal contains CH_4 which was formed during the coalification process. Most will have been naturally

released from the ground surface before mine development, but mining releases the CH_4 remaining in coal beds into the atmosphere. In addition, some of the coal mines still emit CH_4 after they have been abandoned. Also relatively low-density CO_2 is included in coal in comparison with CH_4, and is emitted to the air through the similar process with the CH_4.

The number of operational coal mines in Japan has decreased and coal production has decreased greatly as well. As a result, the amount of CH_4 emissions from coal mining has decreased year by year.

Furthermore, the coal mining practices have changed recently, resulting in the decreasing trend of CH_4 IEF. Specifically, coal is now mined in more shallow areas. Therefore, emitting less CH_4. This is because deep areas are costly to mine compared to coal in shallow areas. Additionally, areas which have been previously mined, thus already releasing CH_4, are re-mined for coal, using the latest technology. This contributes to low CH_4 emissions per amount of coal mined, even if compared with other countries.

b) Methodological Issues

- ***Estimation Method***

➢ *CH_4*

- ***Mining Activities***

CH_4 emissions from mining activities are drawn from actual measurements obtained from individual coal mines using the Tier 3 method, in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 4.11, Fig. 4.1.1).

- ***Post-Mining Activities***

CH_4 emissions from post-mining activities are estimated using the Tier 1 method, which uses default emission factors in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 4.11, Fig. 4.1.1). The emissions are estimated by multiplying the amount of coal mined from underground mines by the emission factor.

- ***Abandoned Underground Mines***

In accordance with the decision tree in the *2006 IPCC Guidelines* (Vol 2, page 4.1.1, Fig4.1.1) and by using the Tier 2 method, the CH_4 emissions from abandoned underground mines are estimated by multiplying the number of abandoned mines, which are not submerged, by emission factors which are established with consideration of types of coal and period of being abandoned as shown in the following equation.

$$E = N * F * ER * EF * CF, \quad EF = (1 + a * T)^b$$

E : Amount of GHG fugitive emissions from abandoned coal mine (kt /year)
N : Number of abandoned mines which was not submerged (sites)
F : The percentage of mines that release fugitive emissions
ER : GHG emissions from mines before mine closure (m^3/year)
EF : Emissions reduction factor
a,b : Parameters determining emission decline curve
T : Time period of mine closure (year)
CF : Gas density (kt /m^3) CH_4: $0.67*10^{-6}$

➢ CO_2

- ***Mining Activities***

CO_2 emissions are estimated by multiplying the production amount of coal by CO_2 emission factor.

- ***Post-Mining Activities***

CO_2 emissions are estimated by multiplying the production amount of coal by CO_2 emission factor.

- ***Abandoned Underground Mines***

The estimation method of CO_2 emissions is similar to that of CH_4 described above, and the CO_2 emission factor is established based on CH_4 emission factor.

● ***Emission Factors***

➢ CH_4

- ***Mining Activities***

CH_4 emission factor for mining activities is established by dividing the total emissions of CH_4 gas identified in a survey by J-COAL (Japan Coal Energy Center), by the production volume of coal from underground mines.

From FY1991 to 1994, since actual measurement data cannot be obtained, the emission factors for those years are interpolated using FY1990 and 1995 values, which are established from actual measurements.

Table 3-58 Emission factors for mining activities –underground mines

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Reference
Coal production of underground mines	kt	6,775	5,622	2,364	738	745	617	536	575	588	543	528	529	540	Surveyed by J-COAL
CH_4 total emissions	1000 m^3	262	92	57	4.2	3.5	2.4	2.0	2.1	2.0	1.8	1.8	1.9	2.3	Surveyed by J-COAL
CH_4 total emissions	kt-CH_4	175.5	61.6	37.9	2.8	2.4	1.6	1.3	1.4	1.3	1.2	1.2	1.2	1.5	=CH_4 [1000m^3] / 1000 × 0.67 [kt/$10^6$$m^3$]
Emission factor	kg-CH_4/t	25.9	11.0	16.0	3.8	3.2	2.6	2.5	2.4	2.2	2.2	2.2	2.3	2.8	CH_4 total emissions

- ***Post-Mining Activities***

Due to the lack of data for emissions from post-mining activities in Japan, the emission factors are calculated as 1.675 [kg-CH_4/t] by converting the average value (2.5 [m^3/t]) of the default values given in the *2006 IPCC Guidelines* with the density of CH_4, 0.67 [kt/10^6 m^3]) at 20°C and 1 atmosphere.

- ***Abandoned Underground Mines***

To establish emission factor for abandoned underground mines, following values are used for the formula on the previous page;

The median of default values which is indicated in Table 4.1.5 in page 4.2.4 in the *2006 IPCC Guidelines* Vol.2 (1990-1925:5%, 1926-1950:26.5%, 1951-1975:40%, 1976-2000:54%, 2001-:54.5%) are used for (*F*), the percentage of mines that release fugitive emissions.

The lower default value (1.3million cubic meter/year/site) indicated in Table 4.1.8 in page 4.27 in the *2006 IPCC Guidelines* Vol.2 is used for (*ER*), GHG emissions from mines before mine closure, by taking scale of mine into consideration.

The coefficients for sub-bituminous coal (a = 0.27, b = -1.00) indicated in Table 4.1.9 in page 4.27 in the *2006 IPCC Guidelines* Vol.2 are used for parameters to determine declining curve for emissions.

➢ CO_2

- ***Mining Activities***

CO_2 emission factor for mining activities is established by multiplying CH_4 emission factor (volume basis) by proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is obtained by using "*Research Report on Gas Chemical Industry Development, FY1960-64*, Reserves in Coal fields" by Hokkaido Development Agency, and by CO_2 density (1.84kt/m^3).

- ***Post-Mining Activities***

In the same way as calculated for mining activities, the emissions factors for post-mining activities are established by multiplying CH_4 emission factor by 0.0088.

- ***Abandoned Underground Mines***

In the same way as calculated for mining activities, the emissions factors for post-mining activities are established by multiplying CH_4 emission factor by 0.0088.

● ***Activity Data***

- ***Mining Activities, Post-Mining Activities***

The values used for activity data for underground mining and post-mining activities are derived by subtracting the surface mining production from the total coal production as given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry and the data provided by J-COAL.

Table 3-59 Trends in coal production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total coal production	kt	7,980	6,317	2,974	1,249	1,351	1,280	1,290	1,206	1,145	1,195	1,247	1,251	1,318
Surface mines		1,205	695	610	511	607	663	754	631	557	652	719	721	778
Underground mines		6,775	5,622	2,364	738	745	617	536	575	588	543	528	529	540

- ***Abandoned Underground Mines***

For activity data, the number of abandoned mines which were not submerged, estimated from the list of abandoned mine in *History of Coal Policy* by J-COAL (Japan Coal Energy Center)

Table 3-60 The number of abandoned mines which were not submerged

Fiscal year of abandonment	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Number of abandoned coal mine without submergence	39	34	28	48	12	32	91	103	61	46	33	42	21	42	29
Fiscal year of abandonment	1971	1972	1973	1974	1975	1976	1977	1978	1980	1987	1989	1992	1994	1995	Total
Number of abandoned coal mine without submergence	13	20	12	1	2	3	1	2	2	2	3	1	1	1	725

● ***Recovery and flaring***

- ***Mining Activities***

There is no flaring activity of CH_4 which has been emitted from the coal bed during mining in Japan, however there are activities of recovering CH_4 and using it as fuel. Therefore the net amount of the emissions is estimated by subtracting the recovered value from the total CH_4 emissions. The values of recovery were provided by the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry (1990-1997) and the data provided by J-COAL (since 1998).

Table 3-61 Trends in CH_4 recovery from mining activities

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Recovery	1000 m^3	50,139	11,112	9,810	2,044	1,288	1,097	988	990	941	733	591	826	448

- ***Post-Mining Activities***

The CH_4 recovery/flaring are reported as "NE," because the existence of such activities has not been confirmed,

- ***Abandoned Underground Mines***

Reported as "NO" since any activities for CH_4 recovery or flaring has not been implemented.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of CH_4 emissions during mining activities, the actual measurement values provided by J-COAL are used for reporting. However, it is difficult to evaluate the uncertainties of these data; therefore, for evaluating the uncertainties, the figures (combined the uncertainty due to measurement error and the uncertainty of error due to the change of flow rate, by using error propagation equation) given in the *2006 IPCC Guidelines* are used, and the uncertainties are established at -5% to +5%. For the uncertainties of CO_2 emissions during mining activity, the uncertainty of CH_4 emissions and the uncertainty of proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is calculated using data provided by Hokkaido Development Agency are combined by error propagation equation, and the uncertainties are established at -19% to +19%.

For the uncertainties in CH_4 emission factors during post-mining activities, since the default values given in the *2006 IPCC Guidelines* are used for the estimation factors, the uncertainty values given in the *2006 IPCC Guidelines* (-33% to +300%) are used. For the uncertainties in CO_2 emission factors during post-mining activities, the uncertainty in CH_4 emission factors and the uncertainty in proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is calculated using data provided by Hokkaido Development Agency are combined by error propagation equation, and the uncertainties are evaluated at -38% to +301%. For the uncertainties in activity data of CH_4 and CO_2, during post-mining activities, the actual measurement values provided by J-COAL are used for reporting. However, it is difficult to evaluate the uncertainties of these data; therefore, for evaluating the uncertainties, the figures given in the *2006 IPCC Guidelines* (-2% to +2%) are used, as a result, the uncertainties in emissions during post-mining activities are evaluated at -33% to +300% for CH_4 emissions and -38% to +301% for CO_2 emissions.

The uncertainties in CH_4 emissions from abandoned mines are established at -50% to +100% based on the description on the uncertainty in Tier 2 given in the *2006 IPCC Guidelines*. For the uncertainties in CO_2 emissions from abandoned mines, the uncertainties in CH_4 emissions and the uncertainties in proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is calculated using data provided by Hokkaido Development Agency, are combined by error propagation equation, and the uncertainties are evaluated at -53% to +102%.

- ***Time-series Consistency***

The CH_4 total emissions data for mining activities in underground mines are consistently derived from J-COAL statistics for FY1990 and since FY1995. From FY1991 to FY1994, time-series consistency is ensured by interpolating the emission factors.

The total coal production and coal production in surface mines are provided by the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry from FY1990 to FY2000. Thereafter, they are provided by J-COAL, because the categories of surface mining production and total coal production in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* are no longer provided. The data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry until 2000 are provided by J-COAL. Therefore, the total coal production data from both of these sources are the same and are used in a consistent manner since FY1990.

The CH_4 recovery data for mining activities are consistent, as were the case for the total coal production and coal production in surface mines.

The numbers of abandoned coal mines, which are the activity data for the abandoned coal mines, are derived from the *Coal Policy History* by J-COAL. The default values in the *2006 IPCC Guidelines* are used for the ratio of gas emitting coal mines, the amount of CH_4 emissions from the coal mine before the closure, and the parameters to determine the decreasing curve of the emissions. Also the CO_2 emissions from the coal mine before closure are estimated from the CH_4 emissions by assuming the ratio of volume is constant, so that the time-series consistency is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

In order to ensure the safety of coal mine workers in Japan, monitoring the concentration of CH_4 and CO in coal mines is ordained by law. Under the law, mining companies must set rules on monitoring management. Mining companies monitor accurately under strict management and checks, and compile relevant reports. Furthermore, national authorities regularly check the monitoring measurements and safety reports.

e) Category-specific Recalculations

There have been no recalculations of emissions from this source category.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.1.1.b. Surface Mines (1.B.1.a.ii.)

a) Category Description

This category provides the estimation methods for fugitive emissions of CH_4 and CO_2 occurring during coal mining and post-mining activities in surface mines. The emissions of CH_4 recovered/flared during coal mining in surface mines are reported as “NE,” because the existence of such activities has not been confirmed.

b) Methodological Issues

- ***Estimation Method***

➢ *CH_4*

- ***Mining Activities***

The CH_4 emissions from mining activities are calculated using the Tier 1 method and the default emission factor in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol.2, page 4.18, Fig.4.1.2).

- ***Post-Mining Activities***

The CH_4 emissions from post-mining activities are calculated using the Tier 1 method and the default emission factor in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol.2, page 4.18, Fig.4.1.2).

Both are calculated by multiplying the amount of coal mined from surface mines by the relevant emission factor.

➢ *CO_2*

- ***Mining Activities***

CO_2 emissions are estimated by multiplying the production amount of coal by CO_2 emission factor.

- ***Post-Mining Activities***

CO_2 emissions are estimated by multiplying the production amount of coal by CO_2 emission factor.

- ***Emission Factors***

➢ *CH_4*

- ***Mining Activities***

The value of 0.804 kg-CH_4/t is used as emission factor for mining activities. It was derived by converting the average (1.2 m^3/t; as the overburden is relatively shallow in surface mines of Japan because of economic reason) of the default values given in the *2006 IPCC Guidelines*, using the concentration of CH_4 at one atmospheric pressure and 20°C (0.67 kt/10^6m^3).

- ***Post-Mining Activities***

The value of 0.067 kg-CH_4/t is used as emission factor for post-mining activities. It was derived by converting the average (0.1 m^3/t) of the default values given in the *2006 IPCC Guidelines*, using the concentration of CH_4 at one atmospheric pressure and 20°C (0.67 kt/10^6m^3).

➢ *CO_2*

- ***Mining Activities***

CO_2 emission factor for mining activities is established by multiplying CH_4 emission factor (volume basis) by proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is obtained by using "*Research Report on Gas Chemical Industry Development, FY1960-64*, Reserves in Coal fields" by Hokkaido Development Agency, and by CO_2 density (1.84kt/m^3).

- ***Post-Mining Activities***

In the same way as calculated for mining activities, the CO_2 emissions factors for post-mining activities are established by multiplying CH_4 emission factor by 0.0088.

- ***Activity Data***

The figure for the surface production given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry and the data provided by the J-COAL were used as activity data for mining and post-mining activities (see Table 3-59).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainty in CH_4 emission factor during mining activities, since the default value given in the *2006 IPCC Guidelines* is used for emission factor, the uncertainty values given in the *2006 IPCC Guidelines* (-50% to +200%) are used. For the uncertainty in CO_2 emission factor during mining activities, the uncertainty in CH_4 emission factor and the uncertainty in proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is calculated using data provided by Hokkaido Development Agency, are combined by error propagation equation, and the uncertainty is calculated as -53% to +201%. For the activity data of CH_4 and CO_2 during mining activities, the actually measured data provided by J-COAL are reported, however it is difficult to evaluate the uncertainty of the data. Therefore, the uncertainty values of -2% to +2% in the *2006 IPCC Guidelines* are used. As a result, the uncertainties in emissions during mining were evaluated at -50% to +200% for CH_4 and -53% to +201% for CO_2.

For the uncertainty in CH_4 emission factor during post-mining activities, since the default value given in the *2006 IPCC Guidelines* is used for emission factor, the values given in the *2006 IPCC Guidelines* (-33% to +300%) are used. For the uncertainty in CO_2 emission factor during post-mining activities, the uncertainty in CH_4 emission factor and the uncertainty in proportion of volume fraction of CO_2 in coalbed gas to that of CH_4, which is calculated using data provided by Hokkaido Development Agency, are combined by error propagation equation, and the uncertainties are evaluated at -38% to +301%. For activity data for CH_4 and CO_2 during post-mining activities, the actual measurement data provided by J-COAL are reported. However, it is difficult to evaluate the uncertainties in these data, the figures (-2% to +2%) given by the *2006 IPCC Guidelines* are used. As a result, the uncertainties in emissions during post-mining activities are evaluated at -33% to +300% for CH_4 and -38% to +301% for CO_2.

- ***Time-series Consistency***

The total coal production and coal production in surface mines were provided by the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry from FY1990 to FY2000. Thereafter, they have been provided by J-COAL, because the categories of surface mining production and total coal production in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* are no longer provided. The data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* prepared by the Ministry of Economy, Trade and Industry until 2000 are provided by J-COAL. Therefore, the total coal production data from both of these sources are the same and have been used in a consistent manner since FY1990.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.1.2. Solid Fuel Transformation (1.B.1.b.)

a) Category Description

This category provides the estimation methods for CH_4 emissions in the process of manufacturing charcoal in the oven; CH_4 emissions are released due to imperfect combustion of carbon contained wood material which is raw material of charcoal.

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from manufacturing charcoal are estimated by multiplying production amount of charcoal by emission factor.

- ***Emission Factors***

The default value given in the *Revised 1996 IPCC Guidelines* (Vol.3, page 1.46, Table 1-14) is used since no default value for this category is provided in the *2006 IPCC Guidelines*. Because the production amount of charcoal is available as a statistical data, the emission factor (1000 kg/TJ) of emitted amount per produced amount in NCV is adopted.

- ***Activity Data***

The activity data is calculated by multiplying the production amount of charcoal by calorific value. The amount of charcoal production is obtained from *Basic Data for Special Forest Product* and *Data for Charcoal* by Forestry Agency. For the calorific value, 30 MJ/kg quoted from the *1996 Revised IPCC Guidelines* (Vol.3, page 1.46, Table 1-14) is adopted.

Table 3-62 The Production Amount of Charcoal

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Charcoal Production	t	83,225	82,278	67,428	44,919	42,345	39,024	37,308	34,449	34,095	31,226	30,263	29,588	29,588

- ***Completeness***

CO_2 are also emitted by charcoal production, however, the emissions are not estimated since they are bio-derived. The emissions by consuming charcoal are included in "1.A Fuel Combustion", however the CO_2 emissions are not included in the national totals but are reported in the CRFs as reference in accordance with the *2006 IPCC Guidelines*.

In Japan, the production of briquettes is considered to meet the description of the activity of solid fuel

transformation. The process of coal briquette production includes introducing water to coal, and squeeze-drying it. Therefore, the process is not thought to involve any chemical reactions, but the emissions of CO_2, CH_4 or N_2O cannot be denied. However, the emissions are not estimated as no actual measurement has been taken and no default value is provided.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for emission factors, the default values given in the *1996 Revised IPCC Guidelines* are used. However, since the uncertainties for emission factors for this source category is not provided in the *1996 Revised IPCC Guidelines*, the uncertainties (-67% to +233%, calculated by 95% confidence interval) for CH_4 emission factors for combustion of wood material provided in the *2006 IPCC guidelines* are substituted.

As for activity data, the uncertainties are evaluated as -50% to +97% by synthesizing the uncertainties for charcoal production (weight base), which are not available in the *Basic Data for Special Forest Product* (Forestry Agency) and then substituted by the uncertainties for coal production, and the uncertainties which are calculated by 95% confidence interval of charcoal calorific value provided in the *2006 IPCC Guidelines* with the error propagation method.

As a result, uncertainties for CH_4 emissions from charcoal production are evaluated as -84% to +252%.

- ***Time-series Consistency***

The data source of the charcoal production amount in FY1990, which is the *Data for Charcoal*, is different from the data source in and after FY1991, which is the *Basic Data for Special Forest Product*. However both data are provided by the Forestry Agency and the data capturing ranges are set to be the same. The default values in the *1996 Revised IPCC Guidelines* are used for the CH_4 calorific value and the emission factor throughout the time-series so that the consistency is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

Surveys whether the default emission factors presented in the *1996 Revised IPCC Guidelines* are suitable for Japan’s circumstances, and studies of necessity in developing country-specific emission factors are necessary.

3.3.1.3. Others (Uncontrollable combustion and burning coal dumps) (1.B.1.c)

This category provides the estimation methods for CO_2 emissions generated by unintentional coal combustion due to mine fire.

As for FY1999, coal combustion was occurred by the fire in Ikejima Coal Mine. However, since the

amount of combusted coal is not available, it is reported as "NE". As for other fiscal years, any fire resulted in coal combustion was not occurred; therefore, it is reported as "NO".

3.3.2. Oil, Natural Gas and Other Emissions from Energy Production (1.B.2.)

3.3.2.1. Oil (1.B.2.a.)

3.3.2.1.a. Exploration (1.B.2.a.i.)

This category provides the estimation methods for fugitive emissions of CO_2, CH_4 and N_2O from the exploratory drilling of oil fields.

In Japan, GHG emissions by the exploratory drilling of oil and natural gas fields are basically only from flaring. Therefore, the fugitive emissions associated with exploratory drilling are included in "1.B.2.c.Flaring.iii Flaring (Combined)".

"1.B.2.a.i. Exploration of Oil" and "1.B.2.b.1 Exploration of Natural Gas" are reported as "IE", because the fugitive emissions other than flaring are also conceptionally included in "1.B.2.c.Flaring.iii Flaring (Combined)" since the default emission factors in the *GPG (2000)*, which covers fugitive emissions other than flaring, are used in "1.B.2.c.Flaring.iii Flaring (combined)" as described later.

3.3.2.1.b. Production (1.B.2.a.ii.)

a) Category Description

This category provides the estimation methods for fugitive emissions of CO_2 and CH_4 occur at production of crude oil and in lowering measuring instrument into well at servicing of operating oil fields.

The emissions associated with fugitive emissions during oil production are estimated for offshore and onshore oil field. The emissions from operating oil fields occur in servicing are reported in "1.B.2.b.ii Production of Natural Gas" and not included in this category, because the activity data of number of wells in production is not able to be divided into the numbers of oil producing wells and natural gas producing wells.

b) Methodological Issues

- ***Estimation Method***

The fugitive emissions from oil production are estimated using the Tier 1 method, in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol. 2, page 4.39, Fig.4.2.2).

- ***Emission Factors***

- ***Production***

For emission factors for fugitive emissions from oil production, the default values for fugitive emissions of conventional oil from offshore and offshore oil fields, which are indicated in the *2006 IPCC Guidelines*, are used. As for emission factors for onshore fields, the medians of default values are used.

Table 3-63 Emission factors for fugitive emissions from oil production [kt/10^3m^3]

		CH_4	CO_2	N_2O 3)
Conventional Oil	Fugitive emissions from offshore fields	5.9×10^{-7}	4.3×10^{-8}	NA
	Fugitive emissions from onshore fields	1.8×10^{-3} 1)	1.3×10^{-4} 2)	NA

Source: *2006 IPCC Guidelines* Vol. 2, page 4.50, Table 4.2.4
1) The default value is 1.5×10^{-6} - 3.6×10^{-3}
2) The default value is 1.1×10^{-7} - 2.6×10^{-4}
3) Excluded from calculations, as the default value is "NA"

- ***Servicing***

As the fugitive emissions from the servicing of oil and natural gas wells are reported in "1.B.2.b.ii Production of natural gas", refer to that section for the emission factors as well.

- ***Activity Data***

- ***Production***

The amount of crude oil production by offshore and onshore oil field (excluding condensate[9]) is used for activity data.

The amount of crude oil production (excluding condensate) is estimated as follows;
The amount of condensate production in offshore gas field is estimated by multiplying the production amount of condensate by the percentage of production volume in offshore in total production volume of natural gas.
The estimated value is deducted from total volume of domestic crude production in offshore oil field to obtain the production amount of crude oil from offshore oil field (excluding condensate).
The production amount of crude oil in onshore oil field (excluding condensate) is estimated by deducting crude oil production in offshore (excluding condensate) from total amount of crude oil production (excluding condensate).

Total production volume of natural gas, crude oil, and condensate is obtained from the data given in the *Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products* and the *Yearbook of Current Production Statistics*. The production amount of natural gas and crude oil from offshore is obtained from *Natural Gas Data Year Book* compiled by the Japan Natural Gas Association.

Table 3-64 Amount of oil production excluding condensate from offshore and onshore oil fields

Item		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oil production excluding condensate	offshore	1000 kl	175	391	167	76	55	81	97	91	78	76	72	70	71
	onshore	1000 kl	245	232	218	295	274	253	243	218	215	208	209	195	191

- ***Servicing***

Because the fugitive emissions from the servicing of oil and natural gas wells are reported in "1.B.2.b.ii Production of natural gas", please refer to that section also for the activity data.

- ***Completeness***

In this category, the amount of crude oil production excluding condensate is used as activity data. The GHG emissions associated with condensate production are included in 1.B.2.b.ii and 1.B.2.b.iii, because emission factors of these categories include emission from condensate production.

9 Light, liquid hydrocarbon that is produced from natural gas wells associated with natural gas production

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties for emission factors established in the *2006 IPCC Guidelines* (-100% to +100%) are used for emission factors for oil production, since the default values in the guidelines are used exclusively. For activity data, because the uncertainty of statistics used for source is not obtained, the values established in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) are used. As a result, the uncertainties for fugitive emissions of CO_2 and CH_4 from oil production are evaluated as -101% to +101% for each.

- ***Time-series Consistency***

Consistent values are used for emission factors from FY1990 to the nearest year, using the above-described method. The activity data for oil production are calculated by using the annual data from the *Yearbook of Mineral Resources and Petroleum Products*, the *Natural Gas Data Year Book* and the *Yearbook of Current Production Statistics* by the consistent estimation method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Since the activity data for FY2013 were obtained, the CO_2 and CH_4 emissions of FY2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

As for the fugitive emissions from the servicing of oil and natural gas wells, the correlative relationships between emissions and production volume of crude oil remains unclear when using estimation method in accordance with the *2006 IPCC Guidelines*, and it is likely that the result of the estimating dos not reflect the actual status. Therefore, the estimation method in the *GPG (2000)* is adopted. In the future, the background information regarding the *2006 IPCC Guidelines* estimation method will be collected, and if new information is obtained, the adoption of the estimation in the *2006 IPCC Guidelines* will be studied.

3.3.2.1.c. Transport (1.B.2.a.iii.)

a) Category Description

This category provides the estimation methods for fugitive emissions of CO_2 and CH_4 occurring during the transportation of crude oil and condensate through pipelines, tank trucks, and tank cars to refineries.

b) Methodological Issues

- ***Estimation Method***

The fugitive emissions from transport of crude oil and condensate are estimated using the Tier 1 method in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol.2, page 4.40, Fig.4.2.3) by multiplying the amount of crude oil and condensate production by the emission factors.

In this category, fugitive emissions from ocean transportation of crude oil which are produced at domestic offshore oil fields and are shipped from ocean to land, and the fugitive emissions from land transportation are estimated. Crude oil is transported on sea entirely by pipeline, and is not expected to generate any fugitive emissions from other transportation modes. Land transport includes a number of methods, including pipeline, tank trucks, and tank cars, but it is difficult to differentiate them statistically. For that reason, the emissions were estimated under the assumption that all of the produced oil is transported by tank trucks and rail cars.

- ***Emission Factors***

The default values given in the *2006 IPCC Guidelines* were used as emission factors.

Table 3-65 Emission factors for transportation of crude oil and condensate [$kt/10^3m^3$]

	CH_4	CO_2	N_2O 1)
Oil Transport/ Tanker Trucks and Rail Cars	2.5×10^{-5}	2.3×10^{-6}	NA
Natural Gas Liquids Transport/ Condensate	1.1×10^{-4}	7.2×10^{-6}	ND

Source: *2006 IPCC Guidelines* Vol. 2, page 4.50 and 4.53, Table 4.2.4
1) Excluded from calculations, as the default value is "NA" or "ND".

- ***Activity Data***

The amount of oil and condensate production in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, all prepared by the Ministry of Economy, Trade and Industry, are used as activity data for fugitive emissions from transport.

Table 3-66 Production of crude oil and condensate in Japan

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oil production excluding condensate	1000 kl	420	623	386	370	329	334	341	310	293	284	281	265	262
Condensate production		234	243	375	541	576	645	633	608	560	541	478	403	365
Oil production (total)		655	866	761	911	905	979	973	917	853	824	759	668	626

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainty of emission factors for CO_2 and CH_4 fugitive emissions from transportation of crude oil and condensate, the values established in the *2006 IPCC Guidelines* (-100% to +100%) are applied since the default values given in the guidelines are used exclusively. As for the uncertainty for activity data, the values established in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) are used since the uncertainties for statistics provided in sources are not available. As a result, the uncertainties for the CO_2 and CH_4 emissions from oil and condensate transport are evaluated to be -101% to +101% for each.

- ***Time-series Consistency***

For the emission factors, consistent values are used from FY1990 to the nearest year with the above-mentioned method. The activity data are calculated based on the annual data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, all prepared by the Ministry of Economy, Trade and Industry, by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.1.d. Refining / Storage (1.B.2.a.iv.)

a) Category Description

This category provides the estimation methods for fugitive emissions of CH_4 occurring when crude oil is refined or stored at oil refineries.

The CO_2 emissions from this source are reported as "NE". Refining/storage activities exist in Japan and an extremely small amount of CO_2 is considered to be released into the atmosphere from these activities if CO_2 is included in crude oil. Because there are neither actual measurements of the CO_2 content of crude oil nor any default values for emission factors, CO_2 emissions from this source are not estimated.

b) Methodological Issues

- ***Estimation Method***

- ***Oil Refining***

The fugitive emissions from oil refining are estimated using the Tier 1 method in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol. 2, page 4.40, Fig. 4.2.3).

- ***Oil Storage***

For the fugitive emissions from oil storage, a country-specific emission factors can be used. Therefore, the emissions are estimated using these factors.

- ***Emission Factors***

- ***Oil Refining***

With respect to the emission factors for fugitive emissions during the refining process, the amount of CH_4 emitted during the crude oil refining process is considered to be negligible because no fugitive emission of CH_4 is likely to occur in Japan during crude oil refining at normal operation. For that reason, the lower limit of the default values shown in the *2006 IPCC Guidelines* is adopted.

Table 3-67 Emission factor during crude oil refining

	Emission factor [kg-CH_4/10^3m^3]
Oil refining	2.6×10^{-6} 1)

Source: *2006 IPCC Guidelines* Vol. 2, page 4.53, Table 4.2.4
1) The default value is 2.6×10^{-6} - 41.0×10^{-6}

- ***Oil Storage***

Oil is stored in either corn-roof tanks or floating-roof tanks. All oil storage in Japan adopts floating-roof tanks, which means that the fugitive CH_4 emissions are considered to be very small. If fugitive CH_4 emissions were to occur, they could only occur by vaporization of oil left on the exposed wall wet with oil when the floating roof descends as the stored oil is removed; thus, the amount of fugitive CH_4 emissions would be small.

The Petroleum Association of Japan has conducted experiments relating to the evaporation of CH_4 from tank walls by making the model of floating-roof tank, and based on the result the CH_4 emissions are estimated.

The emission factor associated with the storage of crude oil is obtained by dividing the emissions estimated by the Petroleum Association (0.007 kt-CH_4/year as of 1998) by the amount of the crude oil put into the oil refining industry.

Table 3-68 Assumptions for calculation of emission factor during oil storage

CH_4 emissions [kt-CH_4/year]	Input of crude oil to oil refining industry [10^3kl]	Emission factor [kt-CH_4/10^3kl]
7×10^{-3}	247,106 [1)]	2.8×10^{-8}

1) Agency for Natural Resources and Energy, *General Energy Statistics*

- ***Activity Data***

The values used for activity data during refining and storing are the values (in volume) of refined NGL (Natural Gas Liquids) and crude oil in the petroleum refining industry taken from the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy.

Table 3-69 Amount of crude oil and NGL refined in Japan

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Oil and NGL refined	10^6m^3	204	241	242	241	231	234	224	210	209	197	197	200	189

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of emission factors for fugitive emissions of CH_4 from refining crude oil and NGL, the values shown in the *2006 IPCC Guidelines* (-100% to +100%) are applied since the default values in the guidelines are used exclusively. The uncertainties for activity data for the fugitive emissions from refining crude oil and NGL are evaluated to be -21% to +21% respectively by error propagation method using the uncertainties of the standard calorific value and statistics used for estimating consumption. However, since the uncertainties of statistical data used for estimating consumption (*Yearbook of Mineral Resources and Petroleum Products* and *Yearbook of the Current Survey of Energy Consumption*) are not available, the default values provided in the *2006 IPCC Guidelines* (the uncertainties associated with measurement of flow rate (excluding sales volumes)) are substituted. As a result, the uncertainties for CH_4 fugitive emissions associated with refining of crude oil and NGL are evaluated at -102% to +102% for each.

As for the uncertainties of emission factors for fugitive emissions of CH_4 during storage of crude oil and NGL, the country-specific values were used. However, it is difficult to evaluate uncertainties; therefore, the values evaluated in the *2006 IPCC Guidelines* (-100% to +100%) are applied. The uncertainties for activity data for the fugitive emissions during storage of crude oil and NGL are evaluated to be -21% to +21% respectively by error propagation method using the uncertainties of

standard calorific value and statistics used for estimating consumption. However, since the uncertainties of statistical data used for estimating consumption (*Yearbook of Mineral Resources and Petroleum Products* and Y*earbook of the Current Survey of Energy Consumption*) are not available, the default values provided in the *2006 IPCC Guidelines* (the uncertainties associated with measurement of flow rate (excluding sales volumes)) are substituted. As a result, the uncertainties for CH_4 fugitive emissions associated with storage of crude oil and NGL are evaluated at -102% to +102% for each.

- ***Time-series Consistency***

Consistent values are used for emission factors from FY1990 to the nearest year by using above–mentioned method. The activity data for refining and storage are calculated using the data from the *General Energy Statistics*, by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

CO_2 and CH_4 emissions in FY2013 were recalculated due to the revision of the fuel consumption in FY2013 in the *General Energy Statistics*. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.1.e. Distribution of Oil Products (1.B.2.a.v.)

Petroleum products are distributed in Japan, and where CO_2 and CH_4 are dissolved, it is conceivable that either or both will be emitted as a result of the relevant activity. The level of CO_2 or CH_4 emitted by the activity is probably negligible in light of the composition of the petroleum products, but because there is no measurement of the CO_2 or CH_4 content in petroleum products, it is not currently possible to calculate emissions. The emissions are reported as “NE” due to the absence of default emission factors.

3.3.2.2. Natural Gas (1.B.2.b.)

3.3.2.2.a. Exploration (1.B.2.b.i.)

This category provides the estimation methods for fugitive emissions of CO_2, CH_4, and N_2O from the explorative drilling of natural gas fields. As well as Exploration of oil (1.B.2.a.i), the emissions in this category are basically only from flaring. Also, it is difficult to distinguish between oil fields and gas fields prior to exploration. Therefore, the emissions are included in 1.B.2.c.Flaring.iii Flaring (combined). In addition, similar to the 1.B.2.a.1 Exploration of Oil, the fugitive emissions other than flaring would be also conceptually included in “1.B.2.c.Flaring.iii Flaring (Combined)”. Therefore, the emissions from this category are reported here as “IE”.

3.3.2.2.b. Production (1.B.2.b.ii.)

a) Category Description

This category provides the estimation methods for fugitive CO_2 and CH_4 emissions from natural gas production and from the lowering work of measuring instruments during the servicing of natural gas wells. The fugitive emissions from natural gas production are estimated by offshore oil fields and onshore oil fields.

b) Methodological Issues

- ***Estimation Method***

The fugitive emissions from the production of natural gas are estimated using Tier 1 method, in accordance with the *2006 IPCC Guidelines* (Vol. 2, page 4.38, Fig. 4.2.1).

For the fugitive emissions related to well servicing, the estimation method of multiplying the amount of crude oil production by emission factors is provided in the *2006 IPCC Guidelines*, however, in Japan, correlation between the amount of crude oil production and the emissions related to well servicing is not clear. Therefore, the Tier1 method provided in the *GPG (2000)* (the estimation method of multiplying the number of production wells by the emission factors), which is considered to be more appropriate for the actual status in Japan, is used

- ***Emission Factors***

- ***Production***

The default values given in the *2006 IPCC Guidelines* are used for the emission factors of fugitive emissions during the production of natural gas.

Table 3-70 Emission factors of fugitive emissions during production of natural gas [kt/10^6 m^3]

		CH_4	CO_2	N_2O 1)
Natural gas production	Fugitive emissions from offshore field	3.8×10^{-4}	1.4×10^{-5}	NA
	Fugitive emissions from onshore field	2.3×10^{-3}	8.2×10^{-5}	NA

Source: *2006 IPCC guidelines* Vol. 2, page 4.48, Table 4.2.4
1) Excluded from calculations, as the default value is "NA".

- ***Servicing***

The default values for fugitive emissions during the servicing of natural gas production wells given in the *GPG (2000)* were used.

Table 3-71 Emission factors during servicing of natural gas production wells [kt/number of wells]

	CH_4	CO_2	N_2O 1)
Production well (servicing)	6.4×10^{-5}	4.8×10^{-7}	0

Source: *GPG (2000)* Table 2.16
1) Excluded from calculations, as the default value is 0 (zero)

- ***Activity Data***

- ***Production***

The production volume of natural gas from offshore in the *Natural Gas Data Year book* published by the Japan Natural Gas Association is used for the production volume of natural gas from offshore gas field. The production volume of natural gas from onshore gas field is estimated by subtracting the production volume of natural gas from offshore gas field above from the total production volume of natural gas in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of*

Current Production Statistics, all prepared by the Ministry of Economy, Trade and Industry.

- ***Servicing***

Because it is impossible to statistically differentiate between oil fields and natural gas fields in the time-series, the total number of oil fields and natural gas fields are used for the estimation. As for activity data for fugitive emissions from well servicing, the number of natural gas and oil wells in production provided in *Natural Gas Data Year Book* by the Japan Natural Gas Association is used. As for the latest fiscal year, the values in the previous fiscal year are provisionally used.

Table 3-72 Natural gas production and the number of natural gas and oil wells in production

Item		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Natural gas production	offshore	10^6m^3	342	374	350	361	355	214	190	191	188	190	196	196	196
	onshore		1,724	1,863	2,149	2,779	3,053	3,515	3,515	3,364	3,155	3,144	2,981	2,744	2,550
	total		2,066	2,237	2,499	3,140	3,408	3,729	3,706	3,555	3,343	3,334	3,177	2,940	2,746
Number of gas and oil wells in production		well	1,230	1,205	1,137	1,115	1,126	1,099	1,065	1,049	1,046	1,047	1,038	1,059	1,059

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of emission factors for fugitive emissions of CO_2 and CH_4 from production of natural gas, the values provided in the *2006 IPCC Guidelines* (-100% to +100%) are applied since the default values in the guidelines are used exclusively. As for the activity data, the values established in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) are used, since the uncertainties for statistical data used as source are not available. As a result, the uncertainties of fugitive emissions of CO_2 and CH_4 from production of natural gas are evaluated to be -101% to +101% for each.

For the emission factors related to servicing of production well, the values established in the *GPG (2000)* (-25% to +25%) are applied since the default values in the guidelines are used exclusively. As for the activity data, the values established in the *2006 IPCC Guidelines* (-25% to +25% of the uncertainties associated with the factor of production facility number) are used, since the uncertainties for statistical data used as source are not available. As a result, the uncertainties of fugitive emissions of CO_2 and CH_4 from servicing of production well are determined to be -35% to +35% for each.

- ***Time-series Consistency***

Consistent values are used for emission factors from FY1990 to the nearest year by using the above-mentioned method. The activity data are calculated by using the data on the production volume of natural gas from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, all prepared by the Ministry of Economy, Trade and Industry, and on the number of oil/natural gas wells from the *Natural Gas Data Year Book.* A consistent method is used throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Since the activity data for FY2013 were obtained, the CO_2 and CH_4 emissions of FY2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.2.c. Processing (1.B.2.b.iii.)

a) Category Description

This category provides the estimation methods for fugitive CO_2 and CH_4 emissions from the processing of natural gas including adjustment of its constituent elements

b) Methodological Issues

- ***Estimation Method***

The fugitive emissions associated with processing natural gas are estimated using Tier 1 method in accordance with the decision tree in the *2006 IPCC Guidelines* (Vol.2, page 4.38, Fig.4.2.1).

- ***Emission Factors***

For the emission factors for the fugitive emissions during processing of natural gas, the median values between upper limit and lower limit indicated in the *2006 IPCC Guidelines* are used.

Table 3-73 Emission factors during natural gas processing [$kt/10^6\ m^3$]

		CH_4	CO_2	N_2O 3)
Natural gas processing	Fugitive emissions from sweet gas plant	7.55×10^{-4} 1)	2.35×10^{-4} 2)	NA

Source: *2006 IPCC Guidelines* Vol. 2, page 4.48, Table 4.2.4
1) The default value of CH_4 is 4.8×10^{-4} - 10.3×10^{-4}
2) The default value of CO_2 is 1.5×10^{-4} - 3.2×10^{-4}
3) Excluded from calculations, as the default value is "NA".

- ***Activity Data***

The production volume of natural gas in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, all prepared by the Ministry of Economy, Trade and Industry, is used as activity data during processing. (Refer to Table 3-72).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of emission factors for fugitive emissions of CO_2 and CH_4 during natural gas processing, the values provided in the *2006 IPCC Guidelines* (-100% to +100%) are applied since the default values in the guidelines are used exclusively. As for the activity data, the values established in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) are used, since the uncertainties of the statistical data used are not available. As a result, the uncertainties of fugitive emissions of CO_2 and CH_4 during natural gas processing are evaluated to be -101% to +101% for each.

- ***Time-series Consistency***

The default values are consistently used for emission factors from FY1990 to the nearest year. The activity data during natural gas processing are calculated by using the data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, all prepared by the Ministry of Economy, Trade and Industry. A consistent method is used throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.2.d. Transmission and Storage (1.B.2.b.iv.)

a) Category Description

This category provides the estimation methods for CH_4 emissions from transmission of domestically produced natural gas, such as the release of gas when relocating and building pipelines, and the release of gas used to operate pressure regulators, and provides the estimation methods for CH_4 emissions from storage facilities of natural gas, such as the emissions occurring by normal operation, regular maintenance, and construction works in receiving domestic LNG (liquefied natural gas) facilities, town gas production facilities, and satellite facilities.

The CO_2 emissions in this source are reported as “NA”. Approximately 90% of town gas is based on LNG and is free of CO_2. However, domestically produced natural gas from some of Japan’s natural gas strata contains CO_2. Because nearly all of this CO_2 is removed at the natural gas production plants before the gas is sent to pipelines, thus almost no CO_2 in natural gas is emitted from natural gas pipelines, and the natural gas provided by town gas suppliers most likely contains no CO_2. The CO_2 emissions removed at natural gas production plants are included in venting (gas) (1.B.2.c.Venting.ii).

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from transmission of natural gas are estimated by multiplying the sales volume of natural gas by the country-specific emission factors.

CH_4 emissions from storage facilities of natural gas are estimated by multiplying the amount of LNG and natural gas, which are utilized as raw material for town gas, by the country-specific emission factors.

- ***Emission Factors***

- ***Transmission***

CH_4 emissions associated with the release of gas from the facilities of Japan Natural Gas Association member companies in relocating and building of pipelines have been surveyed in FY2004, FY2008 and onward; and CH_4 emissions associated with the release of gas used to operate pressure regulators have been surveyed in FY2004, FY2011 and onward by Japan Natural Gas Association. To establish country-specific emission factors for Japan, the results of the surveys are used.

The emission factors for emissions from relocating and building of pipelines, and for emissions from the release of gas used to operate pressure regulators are estimated respectively as shown in the following Table 3-74 and the total values are applied to the emission factors. For the sales volume of natural gas which is used for establishing emission factors, the data are sourced from the member companies of Japan Natural Gas Association and provided by the association.

Table 3-74 The method of estimating emission factors of natural gas transmission

<table>
<tr><th>Fiscal year</th><th>Relocation and building work of pipeline</th><th>Release of gas used to operate pressure regulators</th></tr>
<tr><td>1990 - 2003</td><td colspan="2">The same value as FY2004 is consistently used.</td></tr>
<tr><td>2004</td><td colspan="2">Estimated by dividing the actual CH_4 emissions in FY2004 by the sales volume of natural gas in the same fiscal year.</td></tr>
<tr><td>2005 - 2007</td><td>Estimated by interpolating the emission factor in FY2004 and that in FY2008 which is estimated by the same method as FY2004.</td><td rowspan="2">Estimated by interpolating the emission factor in FY2004 and that in FY2011 which is estimated by the same method as FY2004.</td></tr>
<tr><td>2008 - 2010</td><td>Estimated by dividing the actual CH_4 emissions in each fiscal year by the sales volume of natural gas in the same fiscal year.</td></tr>
<tr><td>2011 -</td><td colspan="2">Estimated by dividing the actual CH_4 emissions in each fiscal year by the sales volume of natural gas in the same fiscal year.</td></tr>
</table>

As a result of the above estimation, the emission factors in each fiscal year are estimated as shown on the Table 3-75.

Table 3-75 The estimation result of emission factors of natural gas transmission [t-$CH_4/10^6m^3$]

Item	-2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pipeline relocation & installation	0.220	0.190	0.160	0.131	0.101	0.100	0.071	0.037	0.073	0.062	0.070
Gas for operating pressure regulators	0.087	0.077	0.067	0.057	0.048	0.038	0.028	0.018	0.013	0.009	0.005
Total	0.306	0.267	0.227	0.188	0.148	0.138	0.099	0.056	0.087	0.071	0.075

- ***Storage***

The emission factor is calculated by dividing the CH_4 emissions actually measured during regular maintenance or construction in the major LNG receiving terminals, town gas production facilities, and satellite terminals in Japan, by the calorific value of the raw material input such as LNG and natural gas. The emission factor calculated using the FY1998 data is 905.41 [kg-CH_4/PJ], while that calculated using the FY2007 data is 264.07 [kg-CH_4/PJ]. The main reason of such change in emission factor is the reduction in CH_4 emissions, which is due to the progress in reduction measures such as the installation of new sampling and recovery lines used for gas analyses (changes to gas recovery lines from atmospheric dispersion) in LNG receiving terminals and town gas production

facilities. Because the measures to reduce CH_4 emissions have been implemented gradually, the emission factors for the period from FY1999 to FY2006 are set by linear interpolation. At the present time, measures to reduce CH_4 emissions have been generally implemented, thereby affording little expectation of any major change in the emission factor for the time being. Therefore, the FY2007 emission factor value is kept for FY2008 and subsequent years.

- ***Activity Data***

- ***Transmission***

The sales volume of natural gas provided in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products* and the *Yearbook of Current Production Statistics*, all by Ministry of Economy, Trade and Industry is used for activity data.

Table 3-76 Sales amount of natural gas

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Natural gas sales amount	10^6m^3	2,067	2,339	2,617	3,329	3,549	3,981	3,911	3,918	4,020	4,208	3,928	3,790	3,792

- ***Storage***

The amount of LNG and natural gas used as raw material for town gas, provided in the *General Energy Statistics* by Agency for Natural Resources and Energy, is used for activity data

Table 3-77 LNG and natural gas used for the feedstock of town gas

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LNG consumption with town gas production	PJ	464	676	864	1,230	1,380	1,468	1,439	1,424	1,553	1,591	1,590	1,548	1,567
Natural gas consumption with town gas production	PJ	40	48	61	86	110	126	131	127	115	128	121	114	115

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

A country-specific emission factor is used for CH_4 emissions from transmission of natural gas, however, since it is difficult to assess the uncertainties, the established values in the *2006 IPCC Guidelines* (-100% to +100%) are applied. As for activity data, because the uncertainties of statistical data used as reference are not available, the established values in the *2006 IPCC Guidelines* (-2% to +2% of the uncertainties associated with measurement of flow rate (sales volumes)) are applied. As a result, the uncertainties of fugitive emissions of CO_2 and CH_4 from natural gas transmission are assessed to be -100% to +100%.

For the emission factors for fugitive CH_4 emissions associated with storage of natural gas, a country-specific emission factor is used; however, since it is difficult to assess the uncertainties, the values established in the *2006 IPCC Guidelines* (-20% to +500%) are applied. As for the activity data, the values established in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) are used, since the uncertainties for statistical data used as source are not available. As a result, the uncertainties of CH_4 fugitive emissions from natural gas storage are assessed to be -25% to +500%.

- ***Time-series Consistency***

Regarding emission factors for transmission of natural gas in and after FY2004, the values are

established by dividing the measured emissions by corresponding natural gas production amount for the fiscal years when emission measurement was implemented. For fiscal years when emission measurement was not implemented, emission factors are established by interpolating. For emissions before FY2003, the established values for FY2004 are used for all fiscal years. In addition, the natural gas sales volume used for activity data is provided in the *Yearbook of Production Supply and Demand of Petroleum, Cool and Coke*, in the *Yearbook of Mineral Resources and Petroleum Products Statistics* and in the *Yearbook of Current Production Statistics* (all by Ministry of Economy, Trade and Industry).

For emission factors for storage of natural gas, as described above and based on the emission factors established from the survey in FY1998 and FY2007, the emission factor for FY1998 is used for before FY1997, the emission factor for FY2007 is used for FY2008 and onward, and the emission factors for FY1999-2006 are established by interpolation using the FY1998 and FY2007 factors.

To ensure the consistency, the figures provided in the *General Energy Statistics* are adopted consistently for activity data of LNG and natural gas which are used as raw material of town gas.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

CO_2 and CH_4 emissions in FY2013 were recalculated due to the revision of the fuel consumption in FY2013 in the *General Energy Statistics*. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.2.e. Distribution (1.B.2.b.v.)

a) Category Description

This category provides the estimation methods for CH_4 emitted from town gas supply networks.

In Japan, liquefied petroleum gas, coal, coke, naphtha, crude oil, and natural gas are refined and blended at gas plants into gas, which, after being conditioned to produce a certain calorific value, is supplied to urban areas through gas lines. Such gas fuel is called “town gas”, of which more than 90% is LNG-based. As for detail of town gas, please refer to the explanation of town gas emission factor in 3.2.1.b. Methodological issues (Figure 3-5, Table 3-12, etc.).

The emissions from CO_2 in this source are reported as “NA”. More than 90% of the town gas is based on LNG and is free of CO_2. However, domestically produced natural gas from some of Japan’s natural gas strata contains CO_2. Because nearly all of this CO_2 is removed at the natural gas production plants before the gas is sent to pipelines, the natural gas provided by town gas suppliers most likely contains no CO_2. The emissions of CO_2 removed at natural gas production plants are included in the venting (gas) (1.B.2.c.Venting.ii).

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from high-pressure pipelines, from medium- and low-pressure pipelines and holders, and from service pipes are calculated by multiplying the sales volume of town gas by the country-specific emission factors.

- ***Emission Factors***

The emission sources in the supply of domestically produced town gas are (i) high-pressure pipelines, (ii) medium- and low-pressure pipelines and holders, and (iii) service pipes. The CH_4 emissions from the town gas pipelines of general gas companies calculated from the actual data by each emission source are shown in Table 3-78. The value of 9.5×10^{-6} kt-CH_4/10^6 m^3, which is obtained by dividing the CH_4 emissions (292 t-CH_4) by the town gas amount sold by general gas companies in the same fiscal year of $30{,}696\times10^6$ m^3 (source: *Gas Industry Yearbook* by Agency for Natural Resources and Energy), is used for the emission factor per sales amount.

Table 3-78 CH_4 emissions from town gas pipelines (FY2004 actual data)

Emission sources		CH_4 emissions [t/year]
High-pressure pipelines	New pipeline installation, and pipeline relocation	180
Medium- and low-pressure pipelines and holders	Construction, demolition, fugitive emissions, inspection of governor and others, holder construction, and overhauling	93
Service pipes	Installation of service pipes, post-installation purging, removal, change of meters, fugitive emissions, go around for opening valves and regular maintenance, and equipment repairs (mainly the emissions occur when the work is done at user sites (homes))	19

- ***Activity Data***

The total of town gas sales amount in calorific value of general gas supplier, pipeline operator, and large scale gas supplier in the *Gas Industry Yearbook* is converted to the value in volume by dividing by the calorific value per volume in the *General Energy Statistics* (Agency for Natural Resources and Energy), and the result is used for the active data.

Table 3-79 The sales amount of town gas

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Genaral gas supplier	PJ	643	872	1,047	1,359	1,413	1,503	1,444	1,416	1,477	1,503	1,520	1,536	1,553
Pipeline operator		NO	NO	NO	31	76	69	85	91	95	110	104	111	108
Large scale gas supplier		NO	5	17	30	26	29	33	39	72	78	64	20	20
Total (above total)	PJ	643	877	1,064	1,419	1,515	1,601	1,563	1,546	1,644	1,691	1,688	1,667	1,681
Calorific value per volume	MJ/m^3	41.9	41.9	41.1	44.8	44.8	44.8	44.8	44.8	44.8	44.8	44.8	40.3	42.5
Total in volume	10^6m^3	15,367	20,952	25,899	31,684	33,811	35,735	34,880	34,516	36,705	37,738	37,686	41,314	39,566

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For emission factor in CH_4 fugitive emissions accompanied by town gas distribution, country-specific figure is used. However, it is difficult to evaluate the uncertainties in this figure; therefore, values (-20% to +500%) provided in the *2006 IPCC Guidelines* are adopted. As for activity data, since it is unable to evaluate the uncertainties in statistical data used for source, the setting values (-2% to +2% of the uncertainties associated with measurement of flow rate (sales volumes)) given in the *2006 IPCC Guidelines* are adopted. As a result, the uncertainties in CH_4 fugitive emissions accompanied

by town gas distribution are evaluated at -20% to +500%

- ***Time-series Consistency***

For the emission factor, the consistent value is used from FY1990 to the nearest year, by using the above-mentioned method. The activity data are calculated using the data from the *Gas Industry Yearbook* with a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Since the activity data for FY2007-2009, 2012 and 2013 were revised, the CH_4 emissions in FY2007-2009, 2012 and 2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.2.f. Industrial plants and power station / residential and commercial sectors (1.B.2.b.vi.)

The conceivable sources of these CH_4 emissions include gas pipe work in buildings, but because these emissions are included in those of "Natural Gas Distribution" (distribution through the town gas network) (1.B.2.b.iv), CH_4 emissions from this source are reported as "IE." Additionally, because CO_2 is basically not included among the town gas constituents, the CO_2 emissions from this source are reported as "NA."

3.3.2.3. Venting and Flaring (1.B.2.c.)

This section includes fugitive emissions of CO_2 and CH_4 occurring from venting during oil field development, crude oil transportation, refining processes, and product transportation in the petroleum industry, as well as during gas field development, natural gas production, transmission, and processing in the natural gas industry.

It also includes CO_2, CH_4 and N_2O emissions from flaring during the above processes.

3.3.2.3.a. Venting (Oil) (1.B.2.c.Venting.i.)

a) Category Description

This category provides the estimation methods for CO_2 and CH_4 emissions from venting in the petroleum industry.

b) Methodological Issues

- ***Estimation Method***

The emissions from venting in the petroleum industry were calculated using the Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 4.39, Fig. 4.2.2) by

multiplying the amount of crude oil production by the default emission factors.

- ***Emission Factors***

The default values for conventional oil given in the *2006 IPCC Guidelines* were used for the emission factors of oil field venting.

Table 3-80 Emission factors of oil field venting

		CH_4	CO_2	N_2O 1)
Oil production/ Conventional oil	Venting [kt/1000 m^3]	7.2×10^{-4}	9.5×10^{-5}	NA

Source: *2006 IPCC Guidelines* Vol. 2, page 4.50, Table 4.2.4
1) Excluded from calculations, as the default value is "NA"

- ***Activity Data***

The production volume of oil in Japan given by the Ministry of Economy, Trade and Industry in its *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, *Yearbook of Mineral Resources and Petroleum Products Statistics* and *Yearbook of Current Production Statistics* is used as activity data of the fugitive emissions from oil field venting. The production of condensate was excluded from the calculation (see Table 3-66).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties in emission factors for CO_2 and CH_4 fugitive emissions from venting (oil), since the default values given in the *2006 IPCC Guidelines* are used for emission factors, the uncertainty values (-50% to +50%) provided in the *2006 IPCC Guidelines* are used. As for activity data, it is unable to evaluate the uncertainties in statistical data used for source, the setting values (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) provided in the *2006 IPCC Guidelines* are used. As a result, the uncertainties in CO_2 and CH_4 fugitive emissions from venting (oil) are evaluated at -52% to +52% for each.

- ***Time-series Consistency***

For the emission factors, consistent values as described above are used from FY1990 to the nearest year. The activity data are calculated using the data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.b. Venting (Gas) (1.B.2.c.Venting.ii.)

a) Category Description

This category source deals with CO_2 emissions accompanied by separation and diffusion of CO_2 which is contained in natural gas produced in natural gas production facilities when CO_2 contents does not meet the standard of non-combustion gas content provided by users.

As for other emission source in this category, intentional CO_2 and CH_4 emissions during transmission of natural gas are considered to be included in this category, because their emission factors are provided in the *2006 IPCC guidelines*. However, the intentional CO_2 emissions from pipeline of natural gas are reported as "NA" in transmission of natural gas (1.B.2.b.iv.) in case of Japan. Therefore, the emissions are not reported. As for CH_4 emissions, the emissions are reported as "IE", because they are included in emissions from transmission of natural gas (1.B.2.b.iv).

b) Methodological Issues

- ***Estimation Method***

For the emissions from this category in FY1990, FY1995 and onward, actual measurement data of CO_2 emission provided by Japan Petroleum Development Association is used for reporting.

For FY1991-1994, the natural gas amount produced from gas field, where separation of CO_2 from natural gas has been implemented (Minami Nagaoka and Katagai gas fields), is used for the activity data, and the emissions are estimated by multiplying the activity data by emissions factors. As for the emission factors, nominal emission factors are estimated by dividing the emissions in FY1990 and FY1995 provided by Japan Petroleum Development Association by activity data in the same fiscal years, and the emission factors for FY1991-1994 are estimated by interpolation using the values for FY1990 and FY1995.

- ***Emission Factors***

For FY1990, FY1995 and onward, the values are estimated by dividing emissions data provided by Japan Petroleum Development Association by activity data. As for FY1991 – FY1994, the values are estimated by interpolation using the values for FY1990 and FY1995.

(For emission estimating purpose, only emission factors for FY1991-1994 are used.)

Table 3-81 Emission factors of natural gas field venting

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Emission factor	kg-CO_2/m^3	0.133	0.117	0.126	0.114	0.112	0.125	0.124	0.123	0.120	0.119	0.122	0.121	0.115

- ***Activity Data***

The total production amount of Minami Nagaoka gas field and Katagai gas field indicated in *Natural Gas Data Year Book* by Japan Natural Gas Association are used for activity data. (For emission estimating purpose, only activity data for FY1991-1994 are used.)

Table 3-82 Production amount of Natural gas from Minami-nagaoka and Katagai gas field

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Minami Nagaoka gas field	10^6 m^3	241	376	571	893	1,244	1,696	1,719	1,632	1,313	1,308	1,372	1,295	1,295
Katagai gas field	10^6 m^3	191	281	219	336	299	299	282	279	346	395	358	369	369
Total	10^6 m^3	432	657	789	1,229	1,543	1,994	2,001	1,911	1,660	1,704	1,731	1,664	1,664

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for emissions from venting (natural gas), actual measurement emission data provided by Japan Petroleum Development Association is used for reporting for FY1990, FY1995 and onward. However, it is difficult to evaluate the uncertainty for the data. Therefore, the standard value of uncertainty associated with measurement of flow rate (-15% to +15%) provided in the *2006 IPCC Guidelines* is adopted.

- ***Time-series Consistency***

For the emissions from this source, the emission data provided by *Japan Petroleum Development Association* are consistently used for FY1990, FY1995 and onward. As for FY1991-1994, the emissions are estimated from the FY1990 and FY1995 emission data provided by *Japan Petroleum Development Association*.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.c. Venting (Combined) (1.B.2.c.Venting.iii.)

Statistical data are reported for two categories of petroleum and natural gas in Japan. As a result, fugitive emissions from venting in the combined petroleum and natural gas industries were reported as “IE” since they were accounted for in the emissions from venting in the petroleum industry (1.B.2.c.i) and the natural gas industry (1.B.2.c.ii)

3.3.2.3.d. Flaring (Oil) (1.B.2.c.Flaring.i.)

a) Category Description

This category provides the estimation methods for CO_2, CH_4, and N_2O from flaring in the petroleum industry.

b) Methodological Issues

- ***Estimation Method***

The CO_2, CH_4, and N_2O emissions from flaring in the petroleum industry were calculated using the Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines*, by multiplying the amount of crude oil production in Japan by the default emissions factors.

- ***Emission Factors***

In the absence of actual measurement data or country-specific emission factors in Japan, the default values shown in the *2006 IPCC Guidelines* were used.

Table 3-83 Emission factors for flaring in the oil industry

	Unit	CH_4	CO_2	N_2O
Flaring (conventional oil)	$kt/10^3 m^3$	2.5×10^{-5}	4.1×10^{-2}	6.4×10^{-7}

Source: *2006 IPCC Guidelines* Vol. 2, p 4.50, Table 4.2.4

- ***Activity Data***

For the calculation of activity data for this emission source, the amounts of crude oil production shown in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Natural Resources and Petroleum Products* and the *Yearbook of Current Production Statistics*, all published by the Ministry of Economy, Trade and Industry, are used. The production of condensate is excluded from the calculation (see Table 3-66).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For emission factors for CO_2, CH_4, and N_2O fugitive emissions from flaring (oil), since the default values given in the *2006 IPCC Guidelines* are used for the emission factors, the setting values (-50% to +50%) provided in the *2006 IPCC Guidelines* are used. As for activity data, it is unable to evaluate the uncertainties in statistical data used for source, the setting values (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) provided in the *2006 IPCC Guidelines* are used. As a result, the uncertainties in CO_2 CH_4, and N_2O fugitive emissions from flaring (oil) are evaluated at -52% to +52% for each.

- ***Time-series Consistency***

For the emission factors, consistent values as described above are used from FY1990 to the nearest year. The activity data of the flaring in oil industry are calculated using the data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.e. Flaring (Gas) (1.B.2.c.Flaring.ii.)

a) Category Description

This category provides the estimation methods for CO_2, CH_4, and N_2O from flaring in the natural gas industry.

b) Methodological Issues

- ***Estimation Method***

The CO_2, CH_4, and N_2O emissions associated with flaring in the natural gas industry were calculated using the Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 2, page 4.38, Fig. 4.2.1). The emissions were calculated by multiplying the amount of natural gas production by the emission factors. The total emissions associated with flaring both during gas production and processing were reported as the emissions from flaring in the natural gas industry.

- ***Emission Factors***

The default values for fugitive emissions from flaring in the natural gas industry given in the *2006 IPCC Guidelines* are used.

Table 3-84 Emission factors for flaring in the natural gas industry

		Unit	CH_4	CO_2	N_2O
Flaring in the natural gas industry	Gas production	$kt/10^6m^3$	7.6×10^{-7}	1.2×10^{-3}	2.1×10^{-8}
	Gas processing/ Sweet gas plant	$kt/10^6m^3$	1.2×10^{-6}	1.8×10^{-3}	2.5×10^{-8}

Source: *2006 IPCC Guidelines* Vol. 2, page 4.48, Table 4.2.4

- ***Activity Data***

For the calculation of activity data for this emission source, the amounts of domestic production of natural gas shown in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Natural Resources and Petroleum Products* and the *Yearbook of Current Production Statistics*, all published by the Ministry of Economy, Trade and Industry, were used (see Table 3-72).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainty of CO_2, CH_4, and N_2O emission factors for flaring (natural gas), the default values given in the *2006 IPCC Guidelines* are used for the emission factors exclusively. Therefore, the uncertainty of -25% to +25% in the *2006 IPCC Guidelines* is applied. For the activity data, the uncertainty of the statistics used is not clear. Therefore, the value in the *2006 IPCC Guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) is used, As a result, the uncertainty of CO_2, CH_4, and N_2O emissions from flaring (natural gas) are evaluated to be -29% to +29% for each.

- ***Time-series Consistency***

For the emission factors, consistent values as described above are used from FY1990 to the nearest year. The activity data of flaring in natural gas industry are calculated using the data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Current Production Statistics*, by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no recalculation of emissions from this source category.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.f. Flaring (Combined) (1.B.2.c.Flaring.iii.)

a) Category Description

In Japan, the statistical data are reported for two categories of oil and natural gas. Therefore, the fugitive emissions which can be distinguished of their category are reported in Flaring (Oil) (1.B.2.c.Flaring.i) or in Flaring (Natural gas) (1.B.2.c.Flaring.ii) respectively. In this category, CO_2, CH_4, and N_2O emissions accompanied by exploration and test before production of oil and natural gas, which are unable to be distinguished of their categories of oil industry or natural gas industry, are reported.

b) Methodological Issues

- ***Estimation Method***

For the fugitive emissions accompanied by exploration and test before production of oil and natural gas, the emission factors, which are established using the crude oil production as activity data, are indicated as default values in the *2006 IPCC Guidelines*.

However, in case of Japan, the correlation between CO_2, CH_4, and N_2O emissions, which are accompanied by exploratory drilling and pre-production testing, and crude oil production, and the correlation between the GHG emissions, which are accompanied by the production during exploration and testing, and the production amount from commercial plants are not clear, thus there is a possibility of deviation between the estimated result and the actual condition, if the estimation method of using the crude oil production as activity data, which is indicated in the *2006 IPCC Guidelines*, is adopted. Therefore the Tier 1 method in *GPG (2000)*, which is considered to be more close to actual condition, is used in this category. The method used is to multiply the activity data of number of exploratory drilling well or testing well by the default emission factor.

- ***Emission Factors***

The default values indicated in the *GPG (2000)* are adopted.

Table 3-85 Emission factors for exploratory drilling and testing wells [kt/number of wells]

	CH_4	CO_2	N_2O
Drilling	4.3×10^{-7}	2.8×10^{-8}	0
Testing	2.7×10^{-4}	5.7×10^{-3}	6.8×10^{-8}

Source: GPG (2000), page 2.86, Table 2.16

- ***Activity Data***

The values described in *Natural Gas Data Year Book* by Japan Natural Gas Association are used for the number of exploratory dilled wells. As for the number of tested wells, it is difficult to grasp statistically, and the tested wells don't always become the succeeded wells. Therefore, the median of the number of wells drilled and the number of wells tested in the *Natural Gas Data Year Book* is used as the number of wells tested. For the most recent year, the data of the previous year are provisionally used.

Table 3-86 Number of wells

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of wells drilled	well	8	7	7	10	7	6	7	4	2	1	4	5	5
Number of wells succeeded		1	3	4	5	2	0	1	2	0	1	2	1	1
Number of wells tested		5	5	6	8	5	3	4	3	1	1	3	3	3

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainty of CO_2, CH_4, and N_2O emission factors for flaring (combined), the default values given in the *GPG (2000)* are used for the emission factors exclusively. Therefore, the uncertainty of -25% to +25% in *GPG (2000)* is applied. For the activity data, the uncertainty of the statistics used is not clear. Therefore, the value in the *2006 IPCC Guidelines* (-25% to +25%: uncertainty accompanied with the factor for number of production facilities) is used, As a result, the uncertainty of CO_2, CH_4, and N_2O emissions from flaring (combined) are evaluated to be -35% to +35% for each.

- ***Time-series Consistency***

For the emission factors, consistent values as described above are used from FY1990 to the nearest year. The activity data are calculated using the data from the *Natural Gas Data Year Book* by a consistent method throughout the time-series from FY1990 to the nearest year.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Since the activity data for FY2013 were obtained, the CO_2 and CH_4 emissions of FY2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.4. Other (Fugitive Emissions Associated with the Geothermal Power Generation) (1.B.2.d.)

a) Category Description

This category deals with the CO_2 and CH_4 emissions in the geothermal power plants, where the CO_2 and CH_4 from the steam production well are emitted from cooling tower into the atmosphere.

b) Methodological Issues

- ***Estimation Method***

The emissions from this source category are estimated by multiplying the amount of steam production (weight base) in each geothermal power plant by mass concentration rate of CO_2 and CH_4, since any descriptions for estimation methods for this category are not provided in the *2006 IPCC guidelines*. However, as for CO_2 and CH_4 in the steam produced in production well, even though there is a possibility that the steam dissolves in water during transmitting in condenser, it is difficult to estimate the dissolved amount. Therefore, the emissions are estimated assuming that the total amount of CO_2 and CH_4 in the produced steam is emitted into the air.

- ***Emission Factors***

Mass concentration rate of CO_2 in steam is estimated by using volume concentration of non-condensable gas in steam and volume concentration of CO_2 in non-condensable gas in each geothermal power plant which is provided in *Directory for Geothermal Power Plant Facilities in Japan* by Japan Geothermal Association (JGA).

Mass concentration rate of CH_4 is estimated by using volume concentration of non-condensable gas in steam in each geothermal power plant which is provided in *Directory for Geothermal Power Plant Facilities in Japan* and concentration of CH_4 in non-condensable gas which is provided in *Geothermal Energy and Greenhouse Gas Emissions* by Geothermal Energy Association.

- ***Activity Data***

The amount of steam production in each geothermal power plant is estimated by multiplying an amount of steam production per hour in each plant provided in *Current Status and Trend of Geothermal Power* by Thermal and Nuclear Power Engineering Society, by operating time of production well which is assumed as same as the power generating time of each power plant in *Current Status and Trend of Geothermal Power* by Thermal and Nuclear Power Engineering Society.

Each emission factor for CO_2 and CH_4 for geothermal power plants in Japan and the trend of the produced amount of steam are indicated in the Table 3-87.

Table 3-87 Emission factor and produced amount of steam of geothermal power plants

Power plant name	Emission factor		Production amount of steam [kt]												
	CO_2 [t-CO_2/kt]	CH_4 [t-CH_4/kt]	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Matsukawa	12.2	0.025	1,884	1,493	1,708	1,115	1,208	1,116	1,257	1,083	813	777	745	872	872
Otake	3.1	0.006	1,173	995	995	774	894	813	928	817	789	677	770	937	937
Onuma	0.6	0.002	694	682	535	651	638	630	628	610	600	590	518	537	537
Onikobe	2.6	0.008	1,018	1,015	1,035	982	1,006	975	896	1,026	1,185	456	348	357	357
Hatchobaru 1	6.5	0.013	2,883	2,366	2,598	2,602	2,420	3,031	2,937	2,783	2,287	2,468	2,353	2,347	2,347
Hatchobaru 2	5.8	0.011	2,514	2,686	2,532	2,452	2,441	2,434	2,516	2,215	2,291	1,943	2,219	2,342	2,342
Kakkonda 1	0.3	0.001	3,498	3,126	1,966	2,021	1,713	2,004	97	1,476	1,535	1,537	1,276	1,374	1,374
Kakkonda 2	0.4	0.001	0	209	1,823	2,004	1,556	1,256	467	1,002	1,440	1,521	1,255	1,269	1,269
Suginoi	8.5	0.019	220	284	203	144	179	151	157	146	129	139	170	140	140
Mori	28.1	0.053	1,367	1,990	1,981	1,501	1,203	1,140	1,200	1,065	1,068	888	1,182	1,001	1,001
Kirishima international hotel	1.1	0.003	48	97	70	0	0	0	0	0	30	81	58	68	68
Uenotai	6.5	0.014	0	1,882	2,070	1,601	1,621	1,500	1,742	1,801	482	1,480	1,846	1,784	1,784
Yamakawa	5.8	0.012	0	1,451	1,336	639	663	901	802	973	1,026	1,151	1,026	989	989
Sumikawa	1.4	0.004	0	3,234	2,846	2,908	2,101	2,700	2,379	2,593	2,611	2,145	1,853	2,038	2,038
Yanaizunishiyama	68.8	0.130	0	3,912	3,425	3,197	3,524	3,264	2,493	1,872	2,229	2,266	2,203	1,626	1,626
Ogiri	0.4	0.001	0	219	2,373	2,306	2,112	2,090	2,216	2,117	2,286	2,079	1,983	1,969	1,969
Takigami	1.9	0.004	0	0	2,111	2,075	2,021	2,143	1,993	2,242	2,239	2,358	2,251	2,374	2,374
Hachijojima	18.1	0.041	0	0	187	156	162	170	164	179	152	171	142	149	149
Kujyu	8.5	0.019	0	0	10	136	133	129	122	129	124	56	26	120	120

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for the emission factors, because the emissions were estimated from the concentration of non-condensable gas in the steam and the concentration of GHG in the non-condensable gas, the uncertainty was estimated at -7% to +7% based on the uncertainty of measurement of gas concentration given in the *2006 IPCC guidelines*. As for the activity data, because the uncertainty of the referred statistics was not available, the values given in the *2006 IPCC guidelines* (-15% to +15% of the uncertainties associated with measurement of flow rate (excluding sales volumes)) were used. As a result, the uncertainty of CO_2 and CH_4 emissions from the steam generated in production well in geothermal production was evaluated as -17% to +17%.

- ***Time-series Consistency***

For the emission factors, consistent values are used from FY1990 to the nearest year, by using the above-mentioned method. The activity data are calculated by a consistent method throughout the time-series from FY1990 to the nearest year, based on the *Current Status and Trend of Geothermal Power*.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines.* The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC procedures are summarized in Chapter 1.

e) Category-specific Recalculations

Since the activity data for FY2008 and 2009 were revised, and the activitiy data for FY2013 were obtained, the CO_2 and CH_4 emissions in FY2008, 2009 and 2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There have been no major planned improvements in this source category.

3.4. CO_2 transport and storage (1.C.)

CO_2 transport and storage sector provides the CO_2 emissions associated with the carbon dioxide capture and storage (CCS). CCS is the technology or methodology that captures the CO_2 which would be emitted to the atmosphere and stores it underground or under seabed.

This sector consists of three categories; transport of CO_2 (1.C.1):— emissions in the stage of CO_2 transport, injection and storage (1.C.2):— emissions in the stage of CO_2 injection and storage, and Other (1.C.3). There are four projects of CO_2 injected underground in the past in Japan. CO_2 Emissions in the stage of transport and injection can occur during the period of injection, and CO_2 emissions in the stage of storage can have occurred continuously since CO_2 is injected. Table 3-88 shows the emissions from CO_2 transport and storage (1.C).

Table 3-88 Past projects of CO_2 underground injection in Japan

Injection site	Period of injection
Kubiki	March 1991 – June 1993
Sarukawa	September 1997 – September 1999
Nagaoka	July 2003 – January 2005
Yubari	November 2004 – October 2007

Table 3-89 CO_2 emissions from CO_2 transport and storage (1.C)

IPCC Category		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1.C.1 Transport of CO_2	a. Pipelines	NE	NO	NO	NE	NE	NE	NO	NO	NO	NO	NO	NO	NO
	b. Ships	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	c. Other	NE	NO	NO	NE	NE	NE	NO	NO	NO	NO	NO	NO	NO
1.C.2 Injection and storage	a. Injection	NE	NO	NO	NE	NE	NE	NO	NO	NO	NO	NO	NO	NO
	b. Storage	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.C.3 Other		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

3.4.1. Transport of CO_2 (1.C.1)

3.4.1.1. Pipelines (1.C.1.a.)

This category provides the fugitive emissions of CO_2 in the stage of CO_2 transport by pipeline.

According to the interview to the entities of the projects shown in Table 3-88, the fugitive emissions in the stage of CO_2 transport by pipeline do not occur basically or the amount is quite small even if the fugitive emissions occur. In addition, the approximate results of emissions estimated using the default emission factor of the *2006 IPCC Guidelines* (vol. 2, page 5.10, Table 5.2) are less than three thousands t-CO_2, which is a criterion to include the emissions in the national totals established by the Committee for the Greenhouse Gases Emissions Estimation Methods. Therefore, the emissions from this category are reported as insignificant NE. (The emissions are reported as NE in the year CO_2 injection was conducted and reported as NO in the other years.) The treatment of insignificant NE is described in Annex 5.

3.4.1.2. Ships (1.C.1.b.)

This category provides the fugitive emissions of CO_2 in the stage of CO_2 transport by ships. The emissions are reported as NO, because ships were not used in the past projects in Japan.

3.4.1.3. Other (1.C.1.c.)

This category provides the fugitive emissions of CO_2 in the stage of liquefied CO_2 transport by a lorry from a plant to an injection site or from a storage tank of liquefied CO_2. It is hard to consider the annual fugitive emissions become larger than three thousands t-CO_2 for following reasons: First, according to the interview to the entities of the projects shown in Table 3-88, the fugitive emissions shown above do not occur basically or the amount is quite small even if the fugitive emissions occur. Second, the maximum amount of annual injection is about six thousands t-CO_2. Therefore, the emissions from this category are reported as insignificant NE. (The emissions are reported as NE in the year CO_2 injection was conducted and reported as NO in the other years.) The treatment of insignificant NE is described in Annex 5.

3.4.2. Injection and Storage (1.C.2)

3.4.2.1. Injection (1.C.2.a.)

This category provides the fugitive emissions of CO_2 in the stage of a compressor or an injection well at an injection site.

According to the interview to the entities of the projects shown in Table 3-88, the fugitive emissions in the stage of injection do not occur basically or the amount is quite small even if the fugitive emissions occur. In addition, the approximate results of emissions estimated using the emission factors shown in Koornneef *et al*. (2008) are less than three thousands t-CO_2, which is a criterion to include the emissions in the national total established by the Committee. Therefore, the emissions from this category are reported as insignificant NE. (The emissions are reported as NE in the year CO_2 injection was conducted and reported as NO in the other years.) The treatment of insignificant NE is described in Annex 5.

3.4.2.2. Storage (1.C.2.b.)

This category provides the fugitive emissions from a storage site.

According to the interview to the entities of the projects shown in Table 3-88, the fugitive emissions from a storage site do not occur basically or the amount is quite small even if the fugitive emissions occur. In addition, the approximate results of emissions estimated using the ratio of stored CO_2 in a storage reservoir to the injected CO_2 shown in the *IPCC (2005)* are less than three thousands t-CO_2, which is a criterion to include the emissions in the national total established by the Committee. Therefore, the emissions from this category are reported as insignificant NE through all reporting years. The treatment of insignificant NE is described in Annex 5.

3.4.3. Information item

This section provides the amount of CO_2 captured for geological storage. Although there is 'Total amount captured for storage' in 'Information item' of CRF table 1.C, it should be noted that amount of

CO_2 captured is subtracted from CO_2 emissions not from 1.C but from categories CO_2 captured.

The amount of CO_2 captured is considered to be nearly equal to that of CO_2 injected in the past projects of geological injection of CO_2 conducted in Japan. Thus, the amount of CO_2 injected that was provided by the entities of the projects is reported as the amount of CO_2 captured in the fiscal years when the injections were conducted. The captured amount is reported in 1.A.1.b Petroleum refining or 2.B.1 Ammonia production in accordance with the source of CO_2 used in each project.

Table 3-90 Amount of CO_2 captured for geological storage

Injection site	Unit	1990	1991	1992	1993	1997	1998	1999	2003	2004	2005	2006	2007	Reported under
Kubiki	kt	0.23	3.93	4.46	1.17	NO	NO	NO	NO	NO	NO	NO	NO	2.B.1 Ammonia production
Sarukawa	kt	NO	NO	NO	NO	2.37	4.87	2.71	NO	NO	NO	NO	NO	2.B.1 Ammonia production
Nagaoka	kt	NO	NO	NO	NO	NO	NO	NO	3.98	6.43	NO	NO	NO	2.B.1 Ammonia production
Yubari	kt	NO	NO	NO	NO	NO	NO	NO	NO	0.04	0.12	0.36	0.37	1.A.1.b Petroleum refining

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Chapter 4. Industrial Processes and Product Use (CRF sector 2)

4.1. Overview of Sector

Chemical and physical transformation in industrial processes releases GHGs into the atmosphere. This chapter describes the methodologies of estimating industrial process and product use emissions shown in Table 4-1. The estimation methods, emission factors, activity data etc of each source are considered and approved by the breakout groups on Energy and Industrial Processes, and F-gases, of the Committee for Greenhouse Gas Emissions Estimation Methods, consisting of experts from various fields. (See Chapter 1)

Emissions have been estimated for all years, with zero emissions for some years and sources. To the extent that space and confidentiality concerns allow, relative indices are shown in the tables under each sub-category. Emissions by each sub-category and by gas are shown in the first table of each category.

Table 4-1 Categories in the industrial processes and product use sector

Source categories				CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
2.A Mineral Industry	2.A.1	Cement Production		○						
	2.A.2	Lime Production		○						
	2.A.3	Glass Production		○						
	2.A.4	Other Process Uses of Carbonates	Ceramics	○						
			Other Uses of Soda Ash	○						
			Non-metallurgical Magnesium Production	IE						
			Other	○						
2.B Chemical Industry	2.B.1	Ammonia Production		○	NE	NA				
	2.B.2	Nitric Acid Production				○				
	2.B.3	Adipic Acid Production		NA		○				
	2.B.4	Caprolactam, Glyoxal and Glyoxylic Acid	Caprolactam			○				
			Glyoxal			○				
			Glyoxylic Acid			○				
	2.B.5	Carbide Production	Silicon Carbide	○	○					
			Calcium Carbide	○	NA					
	2.B.6	Titanium Dioxide Production		○						
	2.B.7	Soda Ash Production		IE						
	2.B.8	Petrochemical and Carbon Black Production	Methanol	NO	NO					
			Ethylene	○	○					
			Ethylene Dichloride and Vinyl Chloride Monomer	○	○					
			Ethylene Oxide	○	○					
			Acrylonitrile	○	NA					
			Carbon Black	○	○					
			Styrene		○					
			Phthalic Anhydride	○						
			Maleic Anhydride	○						
			Hydrogen	○						
	2.B.9	Fluorochemical Production	By-product Emissions: Production of HCFC-22				○			
			Fugitive emissions				○	○	○	○
2.C Metal Production	2.C.1	Iron and Steel Production	Steel	IE	NA					
			Pig Iron	IE	NA					
			Direct Reduced Iron	IE	IE					
			Sinter	IE	IE					
			Pellet	IE	IE					
			Use of Electric Arc Furnaces in Steel Production	○	○					
			Limestone and dolomite use in Iron and Steel Product	○						
	2.C.2	Ferroalloys Production		IE	○					
	2.C.3	Aluminium Production	By-product Emissions	IE				○		
			F-gases Used in Foundries						NO	
	2.C.4	Magnesium Production					○		○	
	2.C.5	Lead Production		IE						
	2.C.6	Zinc Production		IE						
2.D Non-energy Products from Fuels and Solvent Use	2.D.1	Lubricant Use		○						
	2.D.2	Paraffin Wax Use		○						
	2.D.3	Other	Urea-based Catalysts	○						
			Road Paving with Asphalt	NE						
			Asphalt Roofing	NE						
2.E Electronics Industry	2.E.1	Integrated Circuit or Semiconductor					○	○	○	○
	2.E.2	TFT Flat Panel Display					○	○	○	○
	2.E.3	Photovoltaics						C		
	2.E.4	Heat Transfer Fluid						IE		

Source categories						CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	NF_3
2.F Product Uses as Substitutes for ODS	2.F.1	Refrigeration and Air-Conditioning	Domestic Refrigeration		manufacturing				○	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
			Commercial Refrigeration	Commercial Refrigeration	manufacturing				○	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				○	NO	NO	NO
				Automatic Vending Machines	manufacturing				○	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
			Transport Refrigeration		manufacturing				IE	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
			Industrial Refrigeration		manufacturing				IE	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
			Stationary Air-Conditioning (Household)		manufacturing				○	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
			Mobile Air-Conditioning (Car Air Conditioners)		manufacturing				○	NO	NO	NO
					stocks				IE	NO	NO	NO
					disposal				IE	NO	NO	NO
	2.F.2	Foam Blowing Agents	Closed Cells	Urethane Foam	manufacturing				○	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				IE	NO	NO	NO
				Extruded Polystyrene Foam	manufacturing				○	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				IE	NO	NO	NO
			Open Cells	High Expanded Polyethylene Foam	manufacturing				○	NO	NO	NO
					stocks				NO	NO	NO	NO
					disposal				NO	NO	NO	NO
	2.F.3	Fire Protection			manufacturing				NO	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				NO	NO	NO	NO
	2.F.4	Aerosols	Metered Dose Inhalers		manufacturing				○	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				IE	NO	NO	NO
			Aerosols		manufacturing				○	NO	NO	NO
					stocks				○	NO	NO	NO
					disposal				IE	NO	NO	NO
	2.F.5	Solvents			manufacturing				NO	NO	NO	NO
					stocks				○	○	NO	NO
					disposal				IE	IE	NO	NO
	2.F.6	Other Applications							IE	NA	NA	NO
2.G Other Product Manufacture and Use	2.G.1	Electrical Equipment			manufacturing						○	
					stocks						○	
					disposal						IE	
	2.G.2	SF_6 and PFCs from Other Product Use	Military Applications		manufacturing					NE	NE	
					stocks					NE	○	
					disposal					NE	NE	
			Accelerators		manufacturing					NE	NE	
					stocks					NO	○	
					disposal					NE	NE	
			Soundproof Windows		manufacturing					NE	NE	
					stocks					NE	NE	
					disposal					NE	NE	
			Adiabatic Properties: Shoes and Tyres		manufacturing					NE	NE	
					stocks					NO	NO	
					disposal					NE	NE	
			Other Railway Silicon Rectifiers		manufacturing					NA	NA	
					stocks					NA	NA	
					disposal					○	NA	
	2.G.3	N_2O from Product Uses	Medical Applications		manufacturing			NO				
					stocks			○				
					disposal			NO				
			Use During Semiconductor/Liquid Crystal Manufacturing		manufacturing			○				
					stocks			NO				
					disposal			NO				
2.H Other	2.H.2	Food and Beverages Industry				○						

○: Emissions reported
Refer to Abbreviations list for notation keys.

In 2014, total GHG emissions from this sector amounted to approximately 89,650 kt-CO_2 eq., accounting for 6.6% of national total emissions (excluding LULUCF) in Japan. The emissions of CO_2, CH_4, and N_2O from this sector have decreased by 35.6% compared to 1990. The emissions of HFCs, PFCs, SF_6, and NF_3 from this sector have increased by 18.9% compared to 1990.

The main driving factors for the decrease in emissions for this sector since FY1990 are the decrease in emissions of HFC-23 produced as a by-product of HCFC-22 production due to regulation under the Act on the Protection of the Ozone Layer Through the Control of Specified Substances and Other Measures (chemical industry), the decrease in CO_2 emissions from cement production (mineral industry) as the clinker production declined, the decrease in N_2O emissions from adipic acid production (chemical industry) as the N_2O abatement equipment came on stream.

The methodological tiers used in the IPPU sector are as shown in the below Table 4-2.

Table 4-2 Methodological tiers used in the IPPU sector

GREENHOUSE GAS SOURCE AND SINK	CO_2		CH_4		N_2O			
CATEGORIES	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor		
2.A. Mineral industry	CS,T2	CS						
2.B. Chemical industry	CS,T1,T2,T3	CS,D	CS,T1	CS	CS,T1,T2,T3	CS,PS		
2.C. Metal industry	NA	NA	CS	CS				
2.D. Non-energy products from fuels and solvent use	D,T1,T2	CS,D	NA	NA	NA	NA		
2.E. Electronic industry								
2.F. Product uses as ODS substitutes								
2.G. Other product manufacture and use					CS	OTH		
2.H. Other	CS		NA	NA	NA	NA		
GREENHOUSE GAS SOURCE AND SINK	**HFCs**		**PFCs**		**SF_6**		**NF_3**	
CATEGORIES	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**	**Method applied**	**Emission factor**
2.A. Mineral industry								
2.B. Chemical industry	T2	CS						
2.C. Metal industry	CS	CS	T2	CS	CS	CS		
2.D. Non-energy products from fuels and solvent use								
2.E. Electronic industry	T2	CS	T2	CS	T2	CS	T2	CS
2.F. Product uses as ODS substitutes	CS	CS,OTH	CS	CS				
2.G. Other product manufacture and use			CS	CS	CS,T1,T2	CS,D		
2.H. Other								

D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country specific method or EF

4.2. Mineral Industry (2.A.)

This category covers CO_2 emissions from the calcination of mineral raw material such as $CaCO_3$, $MgCO_3$, Na_2CO_3, etc. This section includes GHG emissions from Cement production (2.A.1.), Lime production (2.A.2.), Glass production (2.A.3.), and Other process uses of carbonates (2.A.4.).

In 2014, emissions from this category were 34,924 kt-CO_2 and represented 2.6% of total GHG emissions (excluding LULUCF). The emissions decreased by 29.0% compared to 1990.

Table 4-3 CO_2 Emissions from 2.A. Mineral Industry

Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	2.A Mineral Products	2.A.1	Cement production		kt-CO_2	38,701	42,142	35,086	32,280	31,991	30,658	28,553	25,308	24,321	24,983	25,625	26,805	26,557
		2.A.2	Lime production		kt-CO_2	6,674	5,795	5,900	6,646	6,788	7,012	6,592	5,365	6,285	5,896	5,679	5,767	5,922
		2.A.3	Glass production		kt-CO_2	153	136	107	122	117	104	82	64	78	80	86	93	93
		2.A.4	Other process uses of carbonates	Ceramics	kt-CO_2	930	1,066	981	737	836	887	847	896	891	869	964	1,017	1,052
				Other uses of soda ash	kt-CO_2	267	250	209	197	188	180	157	136	145	144	140	142	146
				Other	kt-CO_2	2,493	1,742	1,617	1,238	1,273	1,359	1,202	1,005	1,028	1,120	1,167	1,229	1,153
	Total				kt-CO_2	49,219	51,131	43,899	41,220	41,192	40,200	37,432	32,776	32,748	33,091	33,661	35,054	34,924

4.2.1. Cement Production (2.A.1.)

a) Category Description

CO_2 is emitted by the calcination of limestone, the main component of which is calcium carbonate, during the production of clinker[1], an intermediate product of cement and the main component of which is calcium oxide. Although to a lesser extent than calcium carbonate, limestone also contains magnesium carbonate, which by calcination emits CO_2.

CO_2 emission mechanism of the cement production process
$CaCO_3 \rightarrow CaO + CO_2$ $MgCO_3 \rightarrow MgO + CO_2$

b) Methodological Issues

- ***Estimation Method***

Following the Tier 2 method in the *2006 IPCC Guidelines*, the CO_2 emissions from this source was estimated by multiplying the amount of clinker produced by a country-specific emission factor.

CO_2 emissions [t-CO_2] from cement production
= emission factor [t-CO_2/t-clinker] × clinker production [t] × cement kiln dust correction coefficient

- ***Emission Factors***

Since Japan's cement industry takes in large amounts of waste and byproducts from other industries and recycles them as substitute raw materials for cement production, clinker contains CaO and MgO from sources other than carbonates. This CaO and MgO do not go through the limestone calcination stage and therefore does not emit CO_2 during the clinker production process. For that reason, emission factors were determined by estimating the CaO and MgO content of clinker from carbonates, by subtracting CaO and MgO originating from waste and other sources from the total CaO and MgO content of clinker. Japan applies 1.00 for the cement kiln dust (CKD) correction coefficient, because normally almost all CKD is recovered and used again in the production process, as confirmed by the Cement Association.

The emission factors for CO_2 emitted from cement production were established as follows.

$$EF = EF_{CaO} + EF_{MgO}$$

EF_{CaO} : $CaCO_3$-origin CO_2 emission factor (established by the following equation)

EF_{MgO} : $MgCO_3$-origin CO_2 emission factor (established by the following equation)

$$EF_{CaO} = \left(CaO_{Cl} - CaO_{Cl-Waste}\right) \times 0.785$$

$$CaO_{Cl-Waste} = \frac{W_{dry} \times CaO_{Waste}}{M}$$

[1] Cement clinker, a black nodule like a volcanic rock with a diameter of 1 cm or so is formed, by introducing a mixture of raw materials such as clay, silica stone, or iron materials, in addition to the main material limestone, into a large rotating kiln after pre-heating, and calcining them under high temperatures, and then rapidly cooling by air. This is ground up, and with the addition of gypsum, is transformed into cement. (from Japan Cement Association's website, partially edited)

CaOcl : CaO content of clinker
CaOcl-waste: CaO content of clinker (waste-origin)
0.785 : Molecular weight ratio of CO_2 to CaO
Wdry : Weight of inputs of waste and other materials (dry)
CaOwaste : CaO content of waste and other materials
M : Production amount of clinker

$$EF_{MgO} = \left(MgO_{Cl} - MgO_{Cl-Waste}\right) \times 1.092$$

$$MgO_{Cl\ \ Waste} = \frac{W_{dry} \times MgO_{Waste}}{M}$$

MgOcl : MgO content of clinker
MgOcl-waste: MgO content of clinker (waste-origin)
1.092 : Molecular weight ratio of CO_2 to MgO
Wdry : Weight of inputs of waste and other materials (dry)
MgOwaste : MgO content of waste and other materials
M : Production amount of clinker

- ***Dry weight of waste and other materials input in raw material processing***

  The following 13 types of waste and other materials were chosen for this calculation: coal ash (incineration residue), sewage sludge incineration ash, municipal solid waste incineration ash, glass refuse/ceramics refuse, concrete refuse, blast furnace slag (water granulated), blast furnace slag (slow-cooled), steelmaking slag, nonferrous slag, casting sand, particulates/dust, coal ash (fluidized bed furnace ash), and coal ash (from dust collectors) (these waste account for over 90% of the CaO and 80% of the MgO from waste and other materials). Waste amounts (emission-based) and the water content of each waste and other material were determined from studies by the Japan Cement Association (only for 2000 and thereafter).

- ***Amount and content of CaO and MgO from waste and other materials in clinker***

  The dry weights of each type of waste and other materials are multiplied by the respective CaO and MgO content for each type as found by the Japan Cement Association, thereby yielding the respective total CaO and MgO amounts in clinker derived from waste and other materials. This is divided by clinker production amount to find the CaO and MgO content from waste and other materials in clinker. As for CaO content, since data for 1990 to 1999 are unavailable, averages for 2000 through 2003 were used. As for MgO content, no data are available for 2006 and earlier years. Therefore, the average for 2007 through 2009 was used.

- ***CaO and MgO content of clinker, excluding the CaO and MgO from waste and other materials***

  CaO and MgO content in waste and other materials is subtracted from the respective average CaO and MgO content of clinker as determined by the Japan Cement Association, which yields the respective proportion of CaO and MgO in clinker that is used to set emission factors.

Table 4-4 Composition of waste-origin material

Group	Types of waste	Water content	CaO content	MgO content
Incineration residue	Coal ash	7.2 - 14.5%	5.0 - 5.8%	1.0 - 1.1%
	Sewage sludge incineration ash *	10.9 - 14.9%	7.4 - 12.5%	3.5 - 3.8%
	Municipal solid waste incineration ash *	19.2 - 24.4%	10.0 - 26.5%	2.6 - 2.8%
Glass refuse, Concrete refuse, and Ceramics refuse	Glass refuse, Ceramics refuse *	12.1 - 32.7%	17.5 - 31.1%	1.0 - 2.5%
	Concrete refuse *	0 - 36.5%	6.4 - 43.9%	1.0 - 1.1%
Slag	Blast furnace slag (water granulated)	5.0 - 16.9%	40.0 - 42.4%	4.7 - 5.8%
	Blast furnace slag (slow-cooled)	5.5 - 7.4%	40.8 - 41.5%	6.1 - 6.5%
	Steelmaking slag	7.7 - 14.1%	34.8 - 40.5%	2.0 - 3.0%
	Nonferrous slag	4.8 - 8.4%	6.4 - 10.0%	1.1 - 1.5%
	Casting sand *	9.8 – 10.9%	6.5%	1.3 - 1.6%
Particulates (dust collector dust)	Particulates/dust	8.9 - 14.3%	9.0 - 13.4%	1.2 - 1.5%
	Coal ash (fluidized bed furnace ash) *	0.1 - 3.2%	14.5 - 20.7%	0.7 - 0.9%
	Coal ash	1.0 - 3.9%	4.6 - 5.0%	1.0 - 1.1%

* Newly added from FY2009.

Table 4-5 CO_2 emission factors for cement production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Average CaO content in clinker	%	65.9	65.9	66.0	65.9	65.9	65.9	65.9	65.8	65.8	65.8	65.8	65.8	65.8
Waste origin CaO content in clinker	%	2.6	2.6	2.9	2.0	2.0	2.0	1.9	1.7	1.7	2.0	1.8	1.7	1.6
CaO content in clinker excluding waste origin CaO	%	63.3	63.3	63.0	63.9	63.9	63.8	63.9	64.1	64.1	63.7	64.0	64.1	64.1
CO_2/CaO		0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785	0.785
Emission factor	t-CO_2/t	0.497	0.497	0.495	0.501	0.501	0.501	0.502	0.503	0.503	0.500	0.502	0.503	0.503
Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Average MgO content in clinker	%	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Waste origin MgO content in clinker	%	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
MgO content in clinker excluding waste origin MgO	%	1.0	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1
CO_2/MgO		1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092	1.092
Emission factor	t-CO_2/t	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012
Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Combined emission factor	t-CO_2/t	0.508	0.508	0.505	0.512	0.513	0.512	0.513	0.514	0.514	0.511	0.514	0.514	0.515

- ***Activity Data***

Cement Association provides the data on the amount of clinker produced. Because there is no statistics on clinker production from 1990 to 1999, an estimation is made for past (1990–1999) clinker production using the average values of the 2000–2003 ratios of clinker production (Cement Association data) to limestone consumption (Ministry of Economy, Trade and Industry, *Yearbook of Ceramics and Building Materials Statistics*).

Table 4-6 Clinker production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Consumption of limestone (actual)	kt (dry)	89,366	97,311	81,376	-	-	-	-	-	-	-	-	-	-
Clinker production (actual)	kt	-	-	69,528	63,003	62,404	59,885	55,647	49,195	47,279	48,884	49,883	52,105	51,573
Clinker production (actual) / Consumption of limestone (actual)*		0.853	0.853											
Estimated clinker production after correction**	kt	76,253	83,032	69,528	63,003	62,404	59,885	55,647	49,195	47,279	48,884	49,883	52,105	51,573

* Clinker Production (actual) / Consumption of Limestone (actual) for 1990-1999 is the average value of 2000-2003.
** Values for FY1990-1999 are corrected using estimation, and values for FY2000 and on are actual.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the CO_2 emission factor and activity data for cement production, the default value given in the *2006 IPCC Guidelines* was applied. As a result, the uncertainty of emissions was estimated to be 4%.

- ***Time-series Consistency***

CO_2 emissions from cement production from 1990 to 1999 is estimated using estimated activity data and emission factors based on values provided by the Japan Cement Association. For years from 2000 and onward, the methodology described in the sections above is consistently applied using the data

provided by Japan Cement Association.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the*2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.2.2. Lime Production (2.A.2.)

a) Category Description

CO_2 is emitted during the calcination of $CaCO_3$, $MgCO_3$ in limestone used as raw material to produce quicklime.

CO_2 generation mechanism of quicklime production process
$CaCO_3 \rightarrow CaO + CO_2$ $MgCO_3 \rightarrow MgO + CO_2$

b) Methodological Issues

- ***Estimation Method***

CO_2 emissions are calculated by multiplying limestone consumption by the country-specific emission factor.

CO_2 emissions [t-CO_2] generated by use of raw materials in quicklime production
= raw material-specific emission factor [t-CO_2/t-raw material] × amount of limestone consumption) [t-product]

- ***Emission Factors***

An emission factor per unit raw material (limestone) (0.428 t-CO_2/t-raw material) provided by the Japan Lime Association was used.

The Emission factor per unit raw material was calculated by finding the CO_2 emissions per unit raw material estimated from the amounts of carbon and other substances in raw material constituents and quicklime products, and then finding the weighted average using production amounts of each district. The emission factor for lime production is the same for all years because annual change is thought to be small. This emission factor is country-specific, as described above.

- ***Activity Data***

Limestone consumption data for quicklime and slaked lime use, categorized under 'Ceramic industry - other ceramics and quarry products' in the Adjusted Price Transaction Table is used. It is converted to dry weight using the water content from limestone used for cement.

The Adjusted Price Transaction Table (RIETI):

The Adjusted Price Transaction Table is a table created from the monetary input table in the Input-Output Table and the consumption data provided in industrial statistics, and is an application of similar estimation methods as in the *General Energy Statistics* (the Energy Balance Table).

In the existing transaction table attached to the Input-Output Table, although expressing the domestic supply and demand of products without any omission/duplication, there exists the possibility of over/under evaluation of transaction depending on the sector if the actual price differs, since transaction in each sector is based on the input from the average price across all industries. In contrast, the Adjusted Price Transaction Table attempts to eliminate differences between sectors, by taking into consideration the uneven transaction prices based on the differences in product quality/form in each sector, and through using statistical values in industrial statistics etc to the extent which possible.

By using consumption data in the Adjusted Price Transaction Table as activity data, it is considered possible to capture activity data for all industries without omission/duplication, and to achieve a correct categorization of emission/non-emission related use, based on its detailed breakdown of sectors.

In the inventory, limestone/dolomite consumption data by sector in the Adjusted Price Transaction Table will be used as activity data for each limestone related source, excluding that for Cement production (2.A.1.).

As for the dolomite consumed in dolomitic lime production, it is accounted for under Other process uses of carbonates (2.A.4.), and therefore will not be included under Lime production (2.A.2.). As for the re-absorption of CO_2 by the production of light calcium carbonate, it is already deducted by accounting for limestone consumption equivalent to the amount of light calcium carbonate production subtracted from lime production, under the lime production sector, in the Adjusted Price Transaction Table.

Table 4-7 Limestone consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Limestone consumption (dry)	kt	15,595	13,540	13,785	15,527	15,860	16,383	15,401	12,534	14,684	13,775	13,269	13,474	13,837

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 2% in the *2006 IPCC Guidelines* was used. For the uncertainty of activity data, the default value of 3% in the *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 4%.

- ***Time-series consistency***

Limestone consumption data provided in the Adjusted Price Transaction Table is used as lime production activity data for all years from FY1990. The emission factors are constant for all years from FY1990. Therefore, CO_2 emission from lime production has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations have been conducted for the whole time-series, based on updates made to limestone consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.2.3. Glass production (2.A.3.)

a) Category Description

Limestone contains $CaCO_3$ and minute amounts of $MgCO_3$, and dolomite contains $CaCO_3$ and $MgCO_3$. The heating of limestone and dolomite releases CO_2 derived from $CaCO_3$ and $MgCO_3$.

CO_2 generating mechanism of limestone and dolomite use
$CaCO_3 \rightarrow CaO + CO_2$ $MgCO_3 \rightarrow MgO + CO_2$

b) Methodological Issues

- ***Estimation Method***

The amounts of limestone and dolomite used in glass production are multiplied by the emission factors to calculate emissions.

- ***Emission Factors***

➢ ***Limestone***

The emission factor is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from limestone (55.4%, the median value of the “54.8% to 56.0%” given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from limestone (0.5%, the median value of the “0.0% to 1.0%” given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific, as shown below. A review of this EF was conducted in 2009, and it was confirmed that it remains valid.

$CaCO_3 \rightarrow CaO + CO_2$

$MgCO_3 \rightarrow MgO + CO_2$

- Proportion of CaO extractable from limestone: 55.4 %
  (Median of 54.8% to 56.0%: Japan Lime Association, The Story of Lime)
- Proportion of MgO extractable from limestone: 0.5 %[b]
  (Median of 0.0% to 1.0%: Japan Lime Association, The Story of Lime)
- Molecular weight of $CaCO_3$ (primary constituent of limestone) : 100.0869[a]
- Molecular weight of $MgCO_3$: 84.3139[a]
- Molecular weight of CaO: 56.0774[a]
- Molecular weight of MgO: 40.3044[a]
- Molecular weight of CO_2: 44.0095[a]
- $CaCO_3$ content = proportion of CaO extractable from limestone × molecular weight of $CaCO_3$ / molecular weight of CaO
- $MgCO_3$ content = proportion of MgO extractable from limestone × molecular weight of $MgCO_3$ / molecular weight of MgO

○Emission factor = (molecular weight of CO_2 / molecular weight of $CaCO_3$ × $CaCO_3$ content)
+ (molecular weight of CO_2 / molecular weight of $MgCO_3$ × $MgCO_3$ content)
= 440 [kg-CO_2/t]

(Sources)
a. IUPAC *"Atomic Weights of the Elements 1999"*
(http://www.chem.qmul.ac.uk/iupac/AtWt/AtWt99.html)
b. Japan Lime Association *"The Story of Lime"*

➢ ***Dolomite***

The emission factor is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from dolomite (34.5%, the median value of the 33.1% to 35.85% range given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from dolomite (18.3%, the median value of the 17.2% to 19.5% range given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific, as shown below. A review of this EF was conducted in 2009, and it was confirmed that it remains valid.

$CaCO_3 \rightarrow CaO + CO_2$
$MgCO_3 \rightarrow MgO + CO_2$

- Proportion of CaO extractable from dolomite: 34.5%
  (Median value of the 33.1% to 35.85% range given in The Story of Lime [Japan Lime Association])
- Proportion of MgO extractable from dolomite: 18.3%
  (Median value of the 17.2% to 19.5% range given in The Story of Lime [Japan Lime Association])
- Molecular weight of $CaCO_3$ (major constituent of dolomite): 100.0869
- Molecular weight of $MgCO_3$ (major constituent of dolomite): 84.3142
- Molecular weight of CaO: 56.0774
- Molecular weight of MgO: 40.3044
- Molecular weight of CO_2: 44.0098

- $CaCO_3$ content = proportion of CaO extractable from dolomite × molecular weight of $CaCO_3$ / molecular weight of CaO
- $MgCO_3$ content = proportion of MgO extractable from dolomite × molecular weight of $MgCO_3$ / molecular weight of MgO

○Emission factor = molecular weight of CO_2 / molecular weight of $CaCO_3$ × $CaCO_3$ content
+ molecular weight of CO_2 / molecular weight of $MgCO_3$ × $MgCO_3$ content
= 471 [kg-CO_2/t]

- ***Activity Data***

Of the limestone and dolomite consumption data in the Adjusted Price Transaction Table, all limestone and dolomite consumption categorized under 'emissive use' that are under the Glass products related sectors will be accounted for under this subcategory. Activity data is in dry weight, converted using the water content from limestone used for cement.

The corresponding sectors in the Adjusted Price Transaction Table are as follows:

Table 4-8 Main uses and corresponding sectors in the Adjusted Price Transaction Table

Use	Corresponding sectors in the Adjusted Price Transaction Table (Limestone)	Corresponding sectors in the Adjusted Price Transaction Table (Dolomite)
Glass products	2511-01 Ceramic industry - sheet glass to 2519-09 Ceramic industry - other glass products	2511-01 Ceramic industry - sheet glass/safety glass

Note: The numbers before the sector names are categorization numbers in the Adjusted Price Transaction Table.

Table 4-9 Amounts of limestone and dolomite consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Limestone consumption (dry)	kt	66	42	26	31	29	25	16	12	17	16	20	24	24
Dolomite consumption (dry)	kt	264	250	203	230	221	197	160	126	151	154	164	176	176

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 5% in the *2006 IPCC Guidelines* was used for both limestone and dolomite. For the uncertainty of activity data, the default value of 3% in the *2006 IPCC Guidelines* was used for both limestone and dolomite. As a result, the uncertainty for emissions was estimated as 6% for both limestone and dolomite.

- ***Time-series consistency***

Limestone and dolomite consumption data provided in the Adjusted Price Transaction Table is used as limestone and dolomite use activity data for all years from FY1990. The emission factors are constant for all years from FY1990. Therefore, CO_2 emission from limestone and dolomite use has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations have been conducted for 2013, based on updates made to limestone and dolomite consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.2.4. Other process uses of carbonates (2.A.4.)

4.2.4.1. Ceramics (2.A.4.a)

a) Category Description

Limestone contains $CaCO_3$ and minute amounts of $MgCO_3$, and dolomite contains $CaCO_3$ and

$MgCO_3$. The heating of limestone and dolomite releases CO_2 derived from $CaCO_3$ and $MgCO_3$.

b) Methodological Issues

- ***Estimation Method***

The amounts of limestone and dolomite used in ceramics production are multiplied by the emission factors to calculate emissions.

- ***Emission Factors***

➢ ***Limestone***

The emission factor (440 [kg-CO_2/t]) is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from limestone (55.4%, the median value of the "54.8% to 56.0%" given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from limestone (0.5%, the median value of the "0.0% to 1.0%" given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific. A review of this EF was conducted in 2009, and it was confirmed that it remains valid. (See 4.2.3. b) for details)

➢ ***Dolomite***

The emission factor (471 [kg-CO_2/t]) is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from dolomite (34.5%, the median value of the 33.1% to 35.85% range given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from dolomite (18.3%, the median value of the 17.2% to 19.5% range given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific. A review of this EF was conducted in 2009, and it was confirmed that it remains valid. (See 4.2.3. b) for details)

- ***Activity Data***

Of the limestone and dolomite consumption data in the Adjusted Price Transaction Table, all limestone and dolomite consumption categorized under 'emissive use' that are under the Ceramics products related sectors will be accounted for under this subcategory. Activity data is in dry weight, converted using the water content from limestone used for cement.

The corresponding sectors in the Adjusted Price Transaction Table are as follows:

Table 4-10 Corresponding sectors in the Adjusted Price Transaction Table

Uses	Corresponding sectors in the Adjusted Price Transaction Table (Limestone)	Corresponding sectors in the Adjusted Price Transaction Table (Dolomite)
Ceramics products		0621-01 Mining industry - raw minerals for ceramics
		0621-09 Mining industry – other non-metal ore
	2531-01 Ceramic industry - pottery, china and earthenware	2531-01 Ceramic industry - ceramics
	2599-01 Ceramic industry - clay refractories	2599-01 Ceramic industry - refractory, -03 carbon graphite
		2599-09 Ceramic industry - other ceramic, stone, and clay products
		2811-01 Metal Products - metal products for construction use to 2899-09 Metal Products - other metal products
		8611-09 Private services – other amusement and recreation services

Note: The numbers before the sector names are categorization numbers in the Adjusted Price Transaction Table.

Table 4-11 Amounts of limestone and dolomite consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Limestone consumption														
For Ceramic Products (dry)	kt	442	1,110	1,138	467	595	659	575	417	400	434	480	729	868
Dolomite consumption														
For Ceramic Products (dry)	kt	1,561	1,227	1,020	1,128	1,218	1,267	1,261	1,514	1,519	1,440	1,597	1,479	1,422

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.2.2. c).

- ***Time-series consistency***

Limestone and dolomite consumption data provided in the Adjusted Price Transaction Table is used as limestone and dolomite use activity data for all years from FY1990. The emission factors are constant for all years from FY1990. Therefore, CO_2 emission from limestone and dolomite use has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations have been conducted for the whole time-series, based on updates made to limestone consumption data in the Adjusted Price Transaction Table. Also recalculations have been conducted for 2005 to 2013, based on updates made to dolomite consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.2.4.2. Other uses of soda ash (2.A.4.b)

a) Category Description

CO_2 is released during the use of soda ash (Na_2CO_3).

b) Methodological Issues

- ***Estimation Method***

CO_2 emissions from soda ash use are calculated by multiplying soda ash consumption by the country-specific emission factor.

- ***Emission Factors***

Soda ash consumption data categorized under 'for emission purpose' in the Adjusted Price Transaction Table does not differentiate between domestic products and imported products, and therefore the emission factor is established by taking a weighted average of the below emission factors for domestic soda ash and imports, by total domestic shipment and total import amounts.

For domestic soda ash, the emission factor is set as follows using data on the purity of soda ash. (The inter-annual fluctuation in the purity of soda ash is small, and therefore the emission factor will be set constant over the time-series.)

Emission factor for domestic soda ash

= purity of soda ash (arithmetic mean between the 2 domestic companies)

× molecular weight of CO_2 / molecular weight of Na_2CO_3

= 0.995 × 44.01 / 105.99

= 0.413

For soda ash imported, and other disodium carbonate imported, there is not enough information to set representative emission factors. Therefore, the default value (0.415 [t-CO_2/t-Na_2CO_3]) specified in the *2006 IPCC Guidelines* (vol. 3 p. 2.7) is used.

- ***Activity Data***

Soda ash consumption data categorized under 'for emission purpose' in the Adjusted Price Transaction Table is used.

Table 4-12 Soda ash consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Soda ash consumption (soda ash)	kt	647	605	504	476	455	435	379	329	349	348	339	344	352

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 5% in the *2006 IPCC Guidelines* was used for both limestone and dolomite. For the uncertainty of activity data, the default value of 3% in the *2006 IPCC Guidelines* was used for both limestone and dolomite. As a result, the uncertainty for

emissions was estimated as 6% for both limestone and dolomite.

- ***Time-series consistency***

Soda ash consumption data provided in the Adjusted Price Transaction Table is used as soda ash use activity data for all years from FY1990. The emission factor is constant for all years from FY1990. Therefore, CO_2 emission from soda ash use has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations have been conducted for the whole time-series, based on updates made to soda ash consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.2.4.3. Non-metallurgical magnesium production (2.A.4.c)

Emissions are included under 2.A.4.d. Other, and are therefore reported as IE.

4.2.4.4. Other (2.A.4.d)

a) Category Description

Limestone contains $CaCO_3$ and minute amounts of $MgCO_3$, and dolomite contains $CaCO_3$ and $MgCO_3$. The heating of limestone and dolomite releases CO_2 derived from $CaCO_3$ and $MgCO_3$.

CO_2 generating mechanism of limestone and dolomite use
$CaCO_3 \rightarrow CaO + CO_2$ $MgCO_3 \rightarrow MgO + CO_2$

b) Methodological Issues

- ***Estimation Method***

The amounts of limestone and dolomite used in desulfurization of exhaust gas and production of chemical products are multiplied by the emission factors to calculate emissions.

- ***Emission Factors***

➢ ***Limestone***

The emission factor is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from limestone (55.4%, the median value of the "54.8% to 56.0%" given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from limestone (0.5%, the median value of the "0.0% to 1.0%" given in

The Story of Lime [Japan Lime Association]). The emission factor is country-specific. A review of this EF was conducted in 2009, and it was confirmed that it remains valid. (See 4.2.3. b) for details)

➢ ***Dolomite***

The emission factor is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from dolomite (34.5%, the median value of the 33.1% to 35.85% range given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from dolomite (18.3%, the median value of the 17.2% to 19.5% range given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific. A review of this EF was conducted in 2009, and it was confirmed that it remains valid. (See 4.2.3. b) for details)

● ***Activity Data***

Of the limestone and dolomite consumption data in the Adjusted Price Transaction Table, all limestone and dolomite consumption categorized under 'emissive use,' that are under the desulfurization of exhaust gas and production of chemical products related sectors will be accounted for under this subcategory. Activity data is in dry weight, converted using the water content from limestone used for cement.

The corresponding sectors in the Adjusted Price Transaction Table are as follows:

Table 4-13 Uses and corresponding sectors in the Adjusted Price Transaction Table

Uses	Corresponding sectors in the Adjusted Price Transaction Table (Limestone)	Corresponding sectors in the Adjusted Price Transaction Table (Dolomite)
Desulfurization of exhaust gas	0621-01 Mining industry - materials for ceramics	
Chemical products	2011-02 Chemical Products - chemical fertilizers	2011-02 Chemical Products - chemical fertilizers
	2022-09 Chemical Products - other inorganic chemical industry products	2022-09 Chemical Products - other inorganic chemical industry products
		2039-02 Chemical Products - processed oil and fat products
	2039-09 Chemical Products - other organic chemical industry products	2039-09 Chemical Products - other organic chemical industry products
		2061-01 Chemical Products - medicaments
		2079-09 Chemical Products – other chemical end products

Note: The numbers before the sector names are categorization numbers in the Adjusted Price Transaction Table.

Table 4-14 Amounts of limestone and dolomite consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Limestone consumption														
For Flue Gas Desulfurization (dry)	kt	1,841	2,139	1,813	2,075	1,995	2,135	1,922	1,699	1,795	2,008	2,149	2,068	1,783
For Chemical Products (dry)	kt	3,668	1,717	1,772	683	840	899	759	531	491	501	481	708	824
Dolomite consumption														
For Chemical Products (dry)	kt	147	96	84	54	54	52	47	52	47	35	20	16	13

c) Uncertainties and Time-series Consistency

● ***Uncertainty***

See section 4.2.3. c).

● ***Time-series consistency***

Limestone and dolomite consumption data provided in the Adjusted Price Transaction Table is used as limestone and dolomite use activity data for all years from FY1990. The emission factors are constant for all years from FY1990. Therefore, CO_2 emission from limestone and dolomite use has been

estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

For desulfurization of exhaust gas, recalculations have been conducted for the whole time-series, based on updates made to limestone consumption data in the Adjusted Price Transaction Table. For production of chemical products, recalculations have been conducted for the whole time-series, based on updates made to limestone consumption data in the Adjusted Price Transaction Table. Also recalculations have been conducted for 2005 to 2013, based on updates made to dolomite consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3. Chemical Industry (2.B.)

This category covers CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3 emissions from the processes of chemical productions.

This section includes GHG emissions from the following sources: Ammonia production (2.B.1.), Nitric acid production (2.B.2.), Adipic acid production (2.B.3.), Caprolactam, glyoxal and glyoxylic acid production (2.B.4), Carbide production (2.B.5.), Titanium dioxide production (2.B.6), Petrochemical and carbon black production (2.B.8), and Fluorochemical production (2.B.9.).

In 2014, emissions from this category were 6,751 kt-CO_2 eq. and represented 0.5% of Japan’s total GHG emissions (excluding LULUCF). The total emissions of CO_2, CH_4, and N_2O from this category had decreased by 65.3% compared to 1990. The total of HFCs, PFCs, SF_6, and NF_3 had decreased by 95.1% compared to 1990.

Table 4-15 Emissions from 2.B. Chemical Industry

Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	2.B Chemical Industry	2.B.1	Ammonia production		kt-CO_2	3,416	3,456	3,183	2,164	2,196	2,256	2,004	1,920	2,119	2,004	1,852	1,930	1,891
		2.B.5	Carbide production	Silicon carbide	kt-CO_2	C	C	C	C	C	C	C	C	C	C	C	C	C
				Calcium carbide	kt-CO_2	C	C	C	C	C	C	C	C	C	C	C	C	C
		2.B.6	Titanium dioxide production		kt-CO_2	102	39	53	59	60	62	51	43	62	65	51	60	62
		2.B.8	Petrochemical and carbon black production	Methanol	kt-CO_2	56.18	50.58	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				Ethylene	kt-CO_2	C	C	C	C	C	C	C	C	C	C	C	C	C
				Ethylene dichloride and vinyl chloride monomer	kt-CO_2	149.83	171.35	192.56	200.44	205.21	199.08	183.71	191.39	184.38	145.79	130.00	147.91	149.80
				Ethylene oxide	kt-CO_2	171.38	190.77	230.67	240.14	233.39	229.76	190.79	190.12	202.28	202.16	203.76	219.54	214.49
				Acrylonitrile	kt-CO_2	439.71	475.64	535.54	509.02	510.50	520.42	411.02	460.76	524.12	485.52	404.02	364.01	341.61
				Carbon black	kt-CO_2	1,633.01	1,562.58	1,590.06	1,659.25	1,714.89	1,731.71	1,493.73	1,307.55	1,504.53	1,379.97	1,260.81	1,294.48	1,253.64
				Phthalic anhydride	kt-CO_2	117.12	124.23	118.10	80.67	66.24	67.77	59.36	51.10	59.64	55.34	60.45	59.19	58.21
				Maleic anhydride	kt-CO_2	123.45	138.37	162.70	113.70	117.56	114.86	95.60	93.91	102.38	90.63	77.84	88.94	88.26
				Hydrogen	kt-CO_2	3.24	17.98	35.64	30.34	28.92	28.16	27.04	28.59	30.77	29.76	27.66	25.17	21.58
	Total				kt-CO_2	7,036	7,010	6,807	5,788	5,867	5,959	5,101	4,866	5,420	5,097	4,645	4,782	4,683
CH_4	2.B Chemical Industry	2.B.5	Carbide production	Silicon carbide	kt-CH_4	C	C	C	C	C	C	C	C	C	C	C	C	C
		2.B.8	Petrochemical and carbon black production	Methanol	kt-CH_4	0.19	0.17	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				Ethylene	kt-CH_4	C	C	C	C	C	C	C	C	C	C	C	C	C
				Ethylene dichloride and vinyl chloride monomer	kt-CH_4	0.01	0.02	0.02	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
				Ethylene oxide	kt-CH_4	C	C	C	C	C	C	C	C	C	C	C	C	C
				Carbon black	kt-CH_4	C	C	C	C	C	C	C	C	C	C	C	C	C
				Styrene	kt-CH_4	C	C	C	C	C	C	C	C	C	C	C	C	C
	Total				kt-CH_4	1.50	1.48	1.37	1.35	1.37	1.21	1.27	1.43	1.45	1.43	1.13	1.13	1.01
	Total				kt-CO_2 eq.	37.49	37.09	34.15	33.69	34.16	30.30	31.74	35.83	36.16	35.64	28.14	28.20	25.22
N_2O	2.B Chemical Industry	2.B.2	Nitric acid production		kt-N_2O	2.47	2.46	2.57	2.52	2.28	1.90	1.62	1.54	1.81	1.49	1.50	1.54	1.55
		2.B.3	Adipic acid production		kt-N_2O	24.20	24.03	12.56	1.68	2.96	0.87	2.45	3.49	1.66	1.05	0.51	0.77	0.48
		2.B.4	Caprolactam, glyoxal and glyoxylic acid production	Caprolactam	kt-N_2O	4.66	4.93	5.20	3.92	3.63	3.66	2.83	3.05	3.17	3.00	2.76	2.35	1.59
				Glyoxal	kt-N_2O	C	C	C	C	C	C	C	C	C	C	C	C	C
				Glyoxylic acid	kt-N_2O	C	C	C	C	C	C	C	C	C	C	C	C	C
	Total				kt-N_2O	32.28	32.43	21.30	9.15	9.88	7.48	7.89	8.45	6.70	5.57	4.76	4.66	3.62
	Total				kt-CO_2 eq.	9,620	9,665	6,348	2,726	2,944	2,228	2,350	2,518	1,995	1,661	1,420	1,389	1,078
Total of CO_2, CH_4, and N_2O					kt-CO_2 eq.	16,693	16,712	13,189	8,547	8,845	8,218	7,483	7,420	7,452	6,794	6,093	6,199	5,786
Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFCs	2.B Chemical Industry	2.B.9	Fluorochemical production	By-product emissions: Production of HCFC-22	kt-CO_2 eq.	15,929	21,460	15,688	586	831	275	593	50	53	16	18	16	24
				Fugitive emissions	kt-CO_2 eq.	2	559	296	449	367	357	306	234	128	151	120	131	101
	Total				kt-CO_2 eq.	15,930	22,019	15,984	1,035	1,198	632	900	284	181	168	138	147	124
PFCs	2.B Chemical Industry	2.B.9	Fluorochemical production	Fugitive emissions	kt-CO_2 eq.	331	914	1,661	1,041	1,091	977	649	459	248	206	148	111	107
SF_6				Fugitive emissions	t	152	197	36	41	57	50	54	10	8	6	5	4	3
					kt-CO_2 eq.	3,471	4,492	821	930	1,303	1,144	1,229	233	189	132	123	93	62
NF_3				Fugitive emissions	t	0.2	1	1	59	47	50	53	56	67	79	62	72	39
					kt-CO_2 eq.	3	19	21	1,018	815	851	915	961	1,152	1,362	1,058	1,230	673
Total of F-gases					kt-CO_2 eq.	19,735	27,444	18,487	4,025	4,408	3,604	3,693	1,937	1,771	1,869	1,467	1,581	966

C: Confidential

4.3.1. Ammonia Production (2.B.1.)

a) Category Description

1) CO_2

In ammonia production, CO_2 is emitted when hydrocarbon feedstock is broken down to make H_2.

CO_2 generating mechanism of ammonia production

$0.88CH_4 + 1.26air + 1.24H_2O \rightarrow 0.88CO_2 + N_2 + 3H_2$

Ammonia synthesis

$N_2 + 3H_2 \rightarrow 2NH_3$

2) CH_4

Emission of CH_4 from the ammonia production has been confirmed by actual measurements. As there are not enough examples to enable the establishment of an emission factor, it is currently not possible to calculate emissions. The *2006 IPCC Guidelines* also do not give a default emission factor. Therefore, CH_4 was reported as "NE".

3) N_2O

Emission of N_2O from ammonia production is theoretically impossible, and given that even in actual measurements the emission factor for N_2O is below the limits of measurement, N_2O was reported as "NA".

b) Methodological Issues

- ***Estimation Method***

CO_2 emissions are calculated by multiplying the amount of fuels consumed as ammonia feedstock by country-specific emission factors. Since carbonated gas, mainly provided from Ammonia production plants, was injected and geologically stored in years 1990 to 1993, 1997 to 1999, 2003, and 2004, this amount is deducted from emissions. (See section 3.4.4 (1.C.) for details)

- ***Emission Factors***

The same emission factors that are used to calculate CO_2 emissions from the fuel combustion sector (Chapter 3) are used for each feedstock listed in Table 4-16. It should be noted that the implied emission factor changes every year, since the composition of the feedstocks consumed for ammonia production varies annually.

Table 4-16 Emission factors and calorific values of feedstocks used when producing ammonia

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Naphtha GCV	MJ/l	33.63	33.63	33.57	33.55	33.55	33.54	33.53	33.53	33.53	33.53	33.53	33.31	33.31
	tC/TJ	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.17	18.63	18.63
LPG GCV	MJ/kg	50.53	50.63	50.70	50.75	50.74	50.73	50.73	50.72	50.77	50.76	50.78	50.07	50.09
	tC/TJ	16.54	16.51	16.49	16.48	16.48	16.48	16.48	16.48	16.47	16.47	16.47	16.38	16.37
Off gas GCV	MJ/m^3	39.35	39.35	44.90	44.90	44.90	44.90	44.90	44.90	44.90	44.90	44.90	46.73	46.73
	tC/TJ	14.15	14.15	14.15	14.15	14.15	14.15	14.15	14.15	14.15	14.15	14.15	14.44	14.44
Natural gas GCV	MJ/m^3	42.09	42.39	42.55	42.87	43.57	44.61	44.71	44.84	44.67	44.74	44.75	40.15	40.15
	tC/TJ	13.90	13.90	13.90	13.90	13.90	13.90	13.90	13.90	13.90	13.90	13.90	13.97	13.97
Coal GCV	MJ/kg	25.95	25.95	26.60	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.70	25.97	25.97
	tC/TJ	24.71	24.71	24.71	24.71	24.71	24.71	24.71	24.71	24.71	24.71	24.71	24.42	24.42
Oil coke GCV	MJ/kg	35.58	35.58	35.60	29.90	29.90	29.90	29.90	29.90	29.90	29.90	29.90	33.29	33.29
	tC/TJ	25.35	25.35	25.35	25.35	25.35	25.35	25.35	25.35	25.35	25.35	25.35	24.50	24.50
LNG GCV	MJ/kg	54.60	54.57	54.55	54.57	54.53	54.55	54.55	54.58	54.60	54.66	54.67	54.99	54.46
	tC/TJ	13.81	13.82	13.82	13.82	13.83	13.82	13.82	13.81	13.81	13.79	13.79	13.71	13.95
COG GCV	MJ/m^3	21.51	21.57	21.27	21.42	21.38	21.28	21.20	21.15	21.32	21.12	20.75	19.12	19.12
	tC/TJ	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.99	10.93	10.93

(Reference) General Energy Statistics, Agency for Natural Resources and Energy

- ***Activity Data***

The fixed units (including weight and volume) for the fuel types in Table 4-17 below, which are from the Ministry of Economy, Trade and Industry's *Yearbook of the Current Survey of Energy Consumption*, were converted using the calorific values in the Agency for Natural Resources and Energy's *General Energy Statistics*, and results were used as activity data. Consumption data on some fuel types are confidential.

Table 4-17 Amount of feedstocks used for ammonia production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Naphtha	kl	189,714	477,539	406,958	92,453	80,755	77,214	67,062	72,045	70,067	67,646	67,869	71,494	66,079
LPG	t	226,593	45,932	5,991	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Off gas	10^3m^3	C	230,972	240,200	147,502	149,927	144,196	151,553	140,783	143,634	126,809	NO	NO	NO
Natural gas	10^3m^3	C	100,468	86,873	77,299	67,225	50,986	50,260	21,773	41,640	41,169	45,808	47,956	51,858
Coal	t	C	209,839	726	1,239	1,066	763	802	522	629	879	390	919	787
Oil coke	t	C	273,125	420,862	353,983	365,068	407,213	336,633	351,594	394,116	365,340	405,557	401,721	426,743
LNG	t	C	46,501	23,395	165,606	180,923	180,161	162,342	145,699	157,918	161,588	169,109	168,155	127,824
COG	10^3m^3	C	35,860	55,333	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

C: Confidential

- ***Point to Note***

Fuel consumption in this category has been deducted from energy sector activity data (see Chapter 3).

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of each fuel was estimated. For the uncertainty of emission factors, the upper limit and lower limit values of the 95% confidence interval for the carbon emission factors were applied. For the uncertainty of the activity data, the same values were applied as in fuel combustion. As a result, the uncertainty of emissions are the following: naphtha -3 - +1%; LPG -3 - +1%; hydrocarbon gas -4 - +3%; natural gas -1 - +1%; coal (steam coal, imported coal) -4 - +3%; petroleum coke -3 - +1%; LNG -1 - +1%; and COG -4 - +3%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series, from the Current Survey of Energy Consumption. The emission factor is constantly based on the *General Energy Statistics* throughout the time series. Therefore, CO_2 emission from ammonia production has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

The gross calorific value and carbon emission factor of LNG was revised for 2013. Recalculations were therefore conducted. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.2. Nitric Acid Production (2.B.2.)

a) Category Description

N_2O is emitted when nitric acid (HNO_3) is produced from ammonia.

<u>N_2O generating mechanism in nitric acid production</u>

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

$2NO + H_2O \rightarrow 2NO_2$

$3NO_2 + H_2O \rightarrow 2HNO_3 + NO \quad (\rightarrow N_2O)$

In Japan, the main processes used in nitric acid production are the New Fauser Process (medium pressure) and Chemico Process (high pressure), both based on the Ostwald chemical process. With regard to N_2O decomposition, there are catalytic decomposition units in operation.

b) Methodological Issues

- ***Estimation Method***

N_2O emissions were estimated by multiplying the nitric acid production amount by an emission factor, based on the Tier 2 method given in the *2006 IPCC Guidelines*. Emission data for individual factories are confidential, and therefore the nitric acid production amount and the emission factor were set for all of Japan. The amount of N_2O destroyed is currently unavailable, but is reflected in the emission factor.

N_2O emissions [kg-N_2O] from nitric acid production
= emission factor [kg-N_2O/t] × nitric acid production volume [t]

- ***Emission Factors***

Data for individual factories are confidential, and therefore the emission factor was set by using each factory's nitric acid production amount to find the weighted average of Japan's 10 nitric acid producing factories' emission factors (measurement data). These emission factors take N_2O recovery and destruction into account.

Table 4-18 N_2O emission factors for nitric acid production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EFs for nitric acid production	kg-N_2O/t	3.50	3.51	3.92	4.18	3.34	3.22	3.35	3.34	3.58	3.49	3.31	3.55	3.54

- ***Activity Data***

Production amounts of nitric acid are directly provided by the Ministry of Economy, Trade and Industry.

Table 4-19 Amount of nitric acid production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Nitric acid production	kt	706	701	656	602	683	590	484	461	506	426	453	434	437

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

As for the uncertainty of the emission factor, the standard deviation was calculated from the emission factors and production amounts of each plant, and was assessed to be 73%. For the uncertainty of activity data, the default value of 2% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated as 73%.

- ***Time-series Consistency***

Emissions throughout the time series are consistently estimated using the activity data and emission factors provided by the Ministry of Economy, Trade and Industry.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.3. Adipic Acid Production (2.B.3.)

a) Category Description

N_2O is emitted in the adipic acid ($C_6H_{10}O_4$) production process through the reaction of cyclohexanone, cyclohexanol, and nitric acid.

b) Methodological Issues

- ***Estimation Method***

Emissions were estimated using the N_2O generation rates, N_2O decomposition amount, and adipic acid production amount of the relevant operating sites, in accordance with the Tier 3 method in the *2006 IPCC Guidelines*.

N_2O emissions from adipic acid production

= [N_2O generation rate × (1 - N_2O decomposition rate × decomposition unit operation rate)]

× adipic acid production amount

- ***Emission Factors***

Values calculated using the above equation have been used as country-specific emission factors. Parameters were established by the following methods. Relevant data used in estimation are confidential.

➢ ***Nitrous oxide generation rate***

Actual measurement data provided from the sole producer of adipic acid as an end product in Japan.

➢ ***Nitrous oxide decomposition rate***

The figure used is the result of measurement of the rate of decomposition of nitrous oxide in the operating site.

➢ ***Decomposition unit operation rate***

A full-scale survey on the number of operation hours is conducted annually for N_2O decomposition units and adipic acid production plants. The operating rate is based on this survey.

Calculation of decomposition unit operation rate

Operation rate of decomposition unit [%]
= Number of hours of decomposition unit in operation
/ Number of hours of adipic acid production plants in operation × 100 [%]

Number of hours of decomposition unit in operation:
Hours starting from the beginning of feeding of the entire amount of N_2O gases until the end of feeding
Number of hours of adipic acid production plants in operation:
Hours starting from the beginning of feeding of raw materials until the end of feeding

- ***Activity Data***

The activity data for nitrous oxide emissions associated with the manufacturing of adipic acid is the amount of adipic acid produced provided to the Ministry of Economy, Trade and Industry by the manufacturer. Relevant data used in estimation is confidential.

- ***Point to Note***

From 1990 to 1997, N_2O emissions from adipic acid production increased gradually. However, N_2O decomposition units were installed in adipic acid production plants in March 1999, and emissions since then have decreased dramatically. There was a temporary growth in the emissions in 2000 due to the low operating ratio of N_2O decomposition units caused by a breakdown of the decomposition units.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of the emission factor for adipic acid was estimated by combining the uncertainty of the N_2O generation rate, N_2O decomposition rate, and the operating rate of the decomposition unit. As a result, the uncertainty of the emission factor was estimated as 9%. A 2% uncertainty given by the *2006 IPCC Guidelines* was applied for activity data. As a result, the uncertainty for adipic acid was estimated as 9%.

- ***Time-series Consistency***

Activity data and emission factors consistently provided by the producer of adipic acid are used to estimate emissions throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.4. Caprolactam, glyoxal and glyoxylic acid production (2.B.4.)

4.3.4.1. Caprolactam Production (2.B.4.a)

a) Category Description

Caprolactam is a monomer for nylon-6 which transforms into Nylon 6 by ring-opening polymerization. Nylon 6 is used as fibers for carpets etc, or resin material. N_2O is emitted from ammonia oxidation during the manufacturing process.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated by multiplying the amount of caprolactam produced by a weighted average emission factor, based on plant-specific emission factors established in accordance with Tier 1 – 3

methods in the *2006 IPCC Guidelines*.

- ***Emission Factors***

A country-specific emission factor per production amount was established by dividing total emissions by total production amounts. This was based on data provided from Japan Chemical Industry Association, including production amounts, emission factors, and emissions for all five plants producing caprolactam in Japan. Each plant's emission factor fluctuates by year.

- ***Activity Data***

Caprolactam production amounts from the *Yearbook of Current Production Statistics – Chemical Industry* compiled by the Ministry of Economy, Trade and Industry were used as activity data.

Table 4-20 Caprolactam production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Caprolactam production	kt	516	546	575	455	470	474	365	401	411	392	366	342	266

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

As for the uncertainty of the emission factor, the standard deviation was calculated from the emission factors and production amounts of each plant, and was assessed to be 99%. For the uncertainty of activity data, the default value of 2% in the *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 99%.

- ***Time-series Consistency***

For the activity data, data from the *Yearbook of Current Production Statistics – Chemical Industry* (METI) are consistently used throughout the time series. The emission factors are constant throughout the time series. Therefore, emissions have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.4.2. Glyoxal Production (2.B.4.b)

a) Category Description

Glyoxal is mainly used as a crosslinking agent for acrylic resins, disinfectant, gelatin hardening agent, and textile finishing agent etc. It's produced from oxidation of acetaldehyde with concentrated nitric acid, or from the catalytic oxidation of ethylene glycol, and N_2O is emitted in the process of oxidation of acetaldehyde. (See below)

$$2C_2H_4O + 2HNO_3 \rightarrow 2C_2H_2O_2 + N_2O + H_2O$$

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated in accordance with the Tier 3 method in the *2006 IPCC Guidelines*, by multiplying the amount of glyoxal produced by an emission factor. There is no production from 2010 onward, and therefore emissions are reported as NO.

- ***Emission Factors***

A country-specific emission factor per production amount based on information provided by the manufacturer was used. This was established based on the amounts of gas emitted in the manufacturing process of each product, and measurements of N_2O concentrations, and will be applied to all years.

- ***Activity Data***

No statistics are available on glyoxal production amounts, and therefore the production amounts at one manufacturer that had been producing until recent were used as activity data. There is no production from 2010 onward.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 10% in the *2006 IPCC Guidelines* was used. For the uncertainty of activity data, the default value of 2% in the *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 10%.

- ***Time-series Consistency***

For the activity data, data from the one manufacturer that had been producing until recent are consistently used throughout the time series. The emission factors are constant throughout the time series. Therefore, emissions have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.4.3. Glyoxylic acid Production (2.B.4.c)

a) Category Description

Glyoxylic acid is used for the production of synthetic aromas, agrochemicals, and pharmaceutical intermediates. It is produced by nitric acid oxidation of glyoxal, and N_2O is emitted in the process of reduction of nitric acid.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated in accordance with the Tier 3 method in the *2006 IPCC Guidelines*, by multiplying the amount of glyoxylic acid produced by an emission factor. There is no production from 2012 onward, and therefore emissions are reported as NO.

- ***Emission Factors***

A country-specific emission factor per production amount based on information provided by the manufacturer was used. This was established based on the amounts of gas emitted in the manufacturing process of each product, and measurements of N_2O concentrations, and will be applied to all years.

- ***Activity Data***

No statistics are available on glyoxylic acid production amounts, and therefore the production amounts at one manufacturer that had been producing until recent were used as activity data. There is no production from 2012 onward.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 10% in the *2006 IPCC Guidelines* was used. For the uncertainty of activity data, the default value of 2% in the *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 10%.

- ***Time-series Consistency***

For the activity data, data from the one manufacturer that had been producing until recent are consistently used throughout the time series. The emission factors are constant throughout the time series. Therefore, emissions have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.5. Carbide Production (2.B.5.)

4.3.5.1. Silicon Carbide Production (2.B.5.a)

a) Category Description

1) CO_2

CO_2 is emitted by the reaction of petroleum coke with silica as raw materials in the production of silicon carbide.

CO_2 generating mechanism in the silicon carbide production process

$SiO_2 + 3C \rightarrow SiC + 2CO \quad (\rightarrow CO_2)$

2) CH_4

In Japan, silicon carbide is produced in electric arc furnaces, and it is believed that CH_4 is generated from the oxidation of coke, which is used as a reducing agent in silicon carbide production.

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions are calculated by multiplying the amount of petroleum coke used as silicon carbide feedstock by an emission factor.

- ***Emission Factors***

Because Japan does not have measurement data or emission factor data, the default value 2.3 [t-CO_2/t] for silicon carbide production in the *2006 IPCC Guidelines* is used.

- ***Activity Data***

The activity data for CO_2 emissions from silicon carbide production is the amount of petroleum coke consumed, provided by Japan's only silicon carbide production facility. The data is confidential.

2) CH_4

- ***Estimation Method***

Emissions were calculated by multiplying an emission factor based on actual figures obtained in Japan by the energy consumption of electric arc furnaces. This is the same method used for calculating CH_4 emissions in the Fuel Combustion Sector (1.A. Solid Fuels).

- ***Emission Factors***

The emission factor of energy consumption in electric arc furnaces (12.8 kg-CH_4/TJ) was determined from CH_4 concentrations in the flue gas, measured dry flue gas amounts per hour, and measured quantity of heat generated per hour. See Chapter 3, 3.2.5 CH_4 and N_2O Emissions from Energy Industry (1.A.1.:CH_4, N_2O)

- ***Activity Data***

The activity data for CH_4 emissions from silicon carbide production is the amount of energy consumed, provided by Japan's only silicon carbide production facility. The data is confidential.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

1) CO_2

For the uncertainty of the emission factor, the default value of 10% was applied as provided by the *2006 IPCC Guidelines*. For the uncertainty of activity data, the default value of 5% given by *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 11%.

2) CH_4

The uncertainty of the emission factor, the default value of 10% was applied as provided by the *IPCC 2006 Guidelines*. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty for emissions was estimated as 11%.

- ***Time-series Consistency***

For both CO_2 and CH_4 activity data, the same sources are consistently used throughout the time series-from the manufacturing facility. The emission factors for both gases are constant throughout the time series. Therefore, CO_2 and CH_4 emissions from silicon carbide have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.5.2. Calcium Carbide Production and Use (2.B.5.b)

a) Category Description

1) CO_2

CO_2 is generated in the process of making the quicklime, and is also emitted by the combustion of CO occurring from calcium carbide production. However, the former is included in emissions from Other process uses of carbonates (2.A.4.), and therefore only reducing agent-origin emissions are accounted for here. Further, CO_2 is generated by the combustion of acetylene, which is generated by reacting calcium carbide with water, and these emissions are reported here.

CO_2 generator mechanism in the calcium carbide production process

(Production)

$$CaCO_3 \rightarrow CaO + CO_2$$

$$CaO + 3C \rightarrow CaC_2 + CO\ (\rightarrow CO_2)$$

(Use)

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2\ (\rightarrow CO_2)$$

2) CH_4

Byproduct gases (mainly CO) generated in carbide production include a small amount of CH_4, all of which is recovered and burned as fuel, with none being emitted outside the system. Therefore, emissions from this source are reported as “NA”.

b) Methodological Issues

- ***Estimation Method***

CO_2 emissions are calculated by multiplying calcium carbide production by the following emission

factor, based on the Tier 2 method in the *2006 IPCC Guidelines*.

- ***Emission Factors***

For years FY1990 to 2007, because Japan does not have measurement data or emission factor data, the below default values in the *2006 IPCC Guidelines* is used.

Table 4-21 CO_2 Emission factors for calcium carbide production and consumption (FY1990-2007)

Units	From reducing agent in production	From use
t-CO_2/t	1.09	1.10

For years after FY2008, country-specific emission factors from reducing agents during production (changes annually) are used, which are based on measurement data from the two calcium carbide producing companies in Japan. These emission factors are confidential.

The default emission factor (1.10 t-CO_2/t) for calcium carbide use is also used for FY2008 and onwards.

- ***Activity Data***

Calcium carbide production data provided by the Carbide Industry Association are used as the calcium carbide production amount. The data are confidential.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the CO_2 emission factor, the 10% default value was applied as provided by the *2006 IPCC Guidelines* for both reducing agent origin and from use. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* for both reducing agent origin and from use. As a result, the uncertainty for emissions for both reducing agent origin and from use was estimated as 11%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant from 1990 to 2007, and for years from 2008 and onward, country-specific emission factors are used. This is because there is no data available on the scale of production or improvements in manufacturing technology to establish country-specific emission factors for earlier years, and therefore default emission factors are used for FY1990 to FY2007.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.6. Titanium dioxide Production (2.B.6)

a) Category Description

Titanium dioxide (TiO_2) is a kind of white pigment, generally used in paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink, and paint etc. The two forms of TiO_2, anatase TiO_2 and rutile TiO_2 (both tetragonal), differ in terms of the crystalline structure, and the anatase TiO_2 is produced by hydrolyzing titanium sulfate and calcination (the sulfate process), or from titanium slag. Rutile TiO_2 is produced through the carbothermal chlorination of rutile ore or synthetic rutile to produce titanium tetrachloride ($TiCl_4$) and oxidation of the $TiCl_4$ vapours to TiO_2. (the chloride route)

CO_2 is emitted from the oxidization of carbon electrodes in the production of titanium slag in electric furnaces, from the oxidization of black coal during the production of synthetic rutile, and from the oxidization of oil coke in the chloride route. The following reactions occur to in the chloride route.

$$2TiO_2 + 4Cl_2 + 3C \rightarrow 2TiCl_4 + 2CO + CO_2$$
$$TiCl_4 + O_2 \rightarrow TiO_2 + 2Cl_2$$

b) Methodological Issues

- ***Estimation Method***

For rutile titanium dioxide, emissions are calculated by multiplying titanium dioxide production amounts (both rutile TiO_2 and anatase TiO_2) produced through the chloride route which entails CO_2 emissions, by an emission factor provided by the manufacturer, based on the Tier 1 method in the *2006 IPCC Guidelines*.

For synthetic rutile, emissions are calculated by multiplying synthetic rutile production amounts by the default emission factor, based on the Tier 1 method in the *2006 IPCC Guidelines*.

- ***Emission Factors***

For rutile TiO_2, an emission factor calculated as follows, based on coke input etc into the process at the manufacturer, is used.

CO_2 emissions = (coke input amount - carry-over amount[2]) x carbon content of coke x 44/12

CO_2 emission factor = CO_2 emissions/titanium dioxide production amounts

Emission factors that can be drawn from the above equation, are only for 2011 to 2013, and therefore for years 1990 – 2010, the average for 2011-2013 are used.

For synthetic rutile, the default value of 1.43 t-CO_2/t from the *2006 IPCC Guidelines* is used.

- ***Activity Data***

For rutile titanium dioxide production amounts, the titanium dioxide amounts produced in the chloride route process (provided by the Japan Titanium Dioxide Industry Association) which entails CO_2 emissions is used.

[2] Raw material left over without reacting.

For synthetic rutile production amounts, synthetic rutile production amounts (provided by METI) is used.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of emission factors for rutile titanium dioxide and synthetic rutile, the default values from the *IPCC 2006 Guidelines* of 15% and 10%, were respectively used. For the uncertainty of activity data, the default value of 5% from the *2006 IPCC Guidelines* was used for both rutile titanium dioxide and synthetic rutile. As a result, the uncertainty of emissions was estimated as 16% and 11%, respectively.

- ***Time-series Consistency***

For the activity data, data from the Japan Titanium Dioxide Industry Association and METI are consistently used throughout the time series. The emission factors are constant throughout the time series. Therefore, emissions have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.7. Soda Ash Production (2.B.7)

In Japan, the ammonium chloride soda process is used to produce soda ash (Na_2CO_3). The soda ash production process involves calcinating limestone and coke in a lime kiln, which emits CO_2. Almost all lime-derived CO_2 is stored in the product.

In the soda ash production process, purchased CO_2 is sometimes input through a pipeline, but because these CO_2 emissions are from the ammonia industry, they are already included in Ammonia production (2.B.1.). Also, the coke consumed is listed as that for heating in the *Yearbook of the Current Survey of Energy Consumption*, and thus CO_2 emissions from coke are already counted under Fuel combustion (1.A.). Therefore all emissions from this source are already included in other categories, and are reported as “IE”. Coke is input as a heat-source and CO_2 source.

The *2006 IPCC Guidelines* offer a method to calculate CO_2 emissions from calcinating trona (Na_2CO_3-$NaHCO_3$-$2H_2O$), but these emissions are not estimated because in Japan soda ash has never been manufactured by trona calcination.

4.3.8. Petrochemical and Carbon Black Production (2.B.8.)

4.3.8.1. Methanol Production (2.B.8.-)

a) Category Description

CO_2 and CH_4 are emitted during the production of methanol.

b) Methodological Issues

- ***Estimation Method***

CO_2 and CH_4 emissions from methanol production are calculated using the Tier 1 method given in the *2006 IPCC Guidelines*.

According to industry organizations, the production (synthesis) of methanol stopped in Japan in 1995 due to the price difference with overseas methanol. Since then all methanol has been imported, and methanol production plants disappeared from Japan in about 1995.

Accordingly, from 1990 to 1995, emissions are reported using the production amounts from industry organization statistics. For 1996 and thereafter, emissions are reported as "NO" because it is assumed that methanol has not been produced (synthesized) since 1995.

- ***Emission Factors***

The default value for CO_2 from methanol given in the *2006 IPCC Guidelines* which corresponds to Japan's country-specific production method was used. The emission factor is 0.67 [t-CO_2/t] (Refer to the *2006 IPCC Guidelines* vol. 3 p 3.73, Table 3.12).

The default value for CH_4 from methanol given in the *2006 IPCC Guidelines* was used. The emission factor is 2.3 [kg-CH_4/t] (Refer to the *2006 IPCC Guidelines* vol. 3 p 3.74).

- ***Activity Data***

Production amounts of methanol (on calendar year basis) given by the Methanol and Formalin Association were used as activity data for CO_2 and CH_4 emissions from methanol production.

Table 4-22 Methanol production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Methanol production	kt	84	75	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default values from the *IPCC 2006 Guidelines* of -30 - +30% (CO_2) and -80 - +30% (CH_4) were used. For the uncertainty of activity data, the default values of similar chemical products from the *IPCC 2006 Guidelines* of -5 - +5% were used. As a result, the uncertainty of CO_2 and CH_4 emissions were estimated as -30 - +30% and -80 - +30%, respectively.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CO_2 and CH_4 emissions from methanol production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

CO_2 emissions were newly estimated. The CH_4 EF was also revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.2. Ethylene Production (2.B.8.-)

a) Category Description

1) CO_2, CH_4

CO_2 is emitted when it is separated in the ethylene production process. CH_4 is emitted by naphtha cracking through steam cracking in the ethylene production process.

Carbon losses in the ethylene production process are accounted for under petrochemicals in the energy conversion sector of the *General Energy Statistics* (Energy Balance Table). The petrochemicals sector represents the process of production of by-products such as refinery gas, fuels, and other oil products, from the factories that produce basic chemical feedstock from naphtha and reformed material oil, by regarding it as energy conversion.

2) N_2O

There is almost no nitrogen contained in naphtha, the raw material of ethylene, and the ethylene production process takes place under conditions that are almost completely devoid of oxygen. Emissions are reported as "NA" in accordance with the judgment of experts that theoretically there are no N_2O emissions.

b) Methodological Issues

- ***Estimation Method***

CH_4 and CO_2 emissions from ethylene production were calculated by multiplying ethylene production by Japan's country-specific emission factor, in accordance with the Tier 1 method in the *2006 IPCC Guidelines*.

- ***Emission Factors***

➢ ***CO_2***

The emission factor was set, based on a survey conducted by the Japan Petrochemical Industry Association in 2009 on the CO_2 emission factor from ethylene production. This emission factor is confidential.

➢ ***CH_4***

Estimates of amount of exhaust gas from flare stacks at a normal operation and an unsteady operation

at operating sites in Japan (assuming that 98% of the amount that enters is combusted[3]), and measured amount of exhaust gas from naphtha cracking furnaces and furnaces heated by re-cycled gas, were divided by the production amount to calculate emission factors for each company. The weighted average based on production from each company was then applied to establish the emission factor. (Surveyed by the Japan Petrochemical Industry Association) This emission factor is confidential.

- ***Activity Data***

Ethylene production amounts from the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used as activity data for emissions of CH_4 and CO_2 from ethylene production.

Table 4-23 Ethylene production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ethylene production	kt	5,966	6,951	7,566	7,549	7,661	7,559	6,520	7,219	6,999	6,474	6,261	6,764	6,687

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty for both CO_2 and CH_4 emission factors for ethylene were calculated by finding the 95% confidence interval of emission factors. The estimated uncertainty for both CO_2 and CH_4 was 77%. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty for both CO_2 and CH_4 was estimated as 77%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CO_2 and CH_4 emissions from ethylene production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.3. 1,2-Dichloroethane and Chloroethylene (2.B.8.-)

a) Category Description

1) CO_2

1,2-dichloroethane (Ethylene Dichloride) is a precursor of polyvinyl chloride, and is mainly used for chloroethylene (VCM) production. It is also used for cleaning agents, solvents, pesticides, and fumigants etc. It is manufactured by the direct chlorination process or the oxychlorination process, or by a process combining the two. The direct chlorination process involves gas-phase reaction of

[3] The assumption was set based on a flaring efficiency of 98% shown in the IPCC GPG (Table 2.16 note e).

ethylene with chlorine to produce ethylene dichloride, and the oxychlorination process involves gas-phase reaction of ethylene with hydrochloric acid and oxygen to produce ethylene dichloride. The oxychlorination process produces CO_2 from the oxidation of the ethylene. (See the below)

$$C_2H_4 + 0.5O_2 + 2HCl \rightarrow C_2H_4Cl_2 + H_2O$$
$$[C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O]$$

The ethylene dichloride is cracked to produce chloroethylene monomer, a precursor of polyvinyl chloride, and hydrochloric acid. The ethylene dichloride is cracked to produce chloroethylene monomer, a precursor of polyvinyl chloride, and hydrochloric acid. Since the hydrochloric acid can be utilized in the oxychlorination prcess, the combined process of the two spread widely. CO_2 is emitted through the same chemical reactions as the above in the combined process.

2) CH_4

1,2-dichloroethane passes through washing, refining, and thermolysis processes to become chloroethylene (C_2H_3Cl). A very small amount of CH_4 is contained in the exhaust gases of the reaction, and of the washing and refining processes.

b) Methodological Issues

- ***Estimation Method***

CO_2 emissions are calculated by multiplying the production amount by Japan's country-specific emission factor, based on plant-specific data, in accordance with the Tier 1 method in the *2006 IPCC Guidelines*.

For years 1990 to 2000, CH_4 emissions are calculated by multiplying the production amount by Japan's country-specific emission factor, based on plant-specific data, in accordance with the Tier 1 method in the *2006 IPCC Guidelines*. According to Vinyl Environmental Council, equipment installation for exhaust gas combustion was completed for all plants, and the CH_4 contained in the tail gas is below detectable levels. Therefore, emissions are reported as NO for years 2001 and onward. (The amount combusted is reported as recovered)

- ***Emission Factors***

  - ***CO_2***

A CO_2 emission factor (0.0647 t-CO_2/tVCM) per chloroethylene production provided by the Vinyl Environmental Council was applied for all years.

This emission factor was established by dividing the total measured CO_2 emissions across all five plants producing 1,2-dichloroethane and chloroethylene in 2012, by the total chloroethylene production amounts in 2012.

The default value 0.294tCO_2/ tVCM also accounts for CO_2 emitted from combustion of auxiliary fuel, but for the above country-specific emission factor, this is removed in order to avoid double-counting with the energy sector, resulting in a lower value than the default.

  - ***CH_4***

The concentration of CH_4 in waste gas from three member companies of the Vinyl Environmental Council (representing approximately 70% of total 1,2-dichloroethane production in Japan) was measured, and a weighted average was calculated to establish the emission factor. (Years 1990 to

2000) The emission factor is 0.0050 [kg-CH_4/t]. Based on the information on the production processes in each Dichloroethane producing company, the representativeness of the EF has been confirmed. (Surveyed by the Vinyl Environmental Council) No emission factors are set for years 2001 and onward.

- ***Activity Data***

VCM (Chloroethylene) production amounts from the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used as activity data for CO_2 emissions

1,2-Dichloroethane production amounts from the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used as activity data for CH_4 emissions.

Table 4-24 VCM (Chloroethylene) production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
VCM production amount	kt	2,316	2,648	2,976	3,098	3,172	3,077	2,839	2,958	2,850	2,253	2,009	2,286	2,315

Table 4-25 1,2-Dichloroethane production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1,2-Dichloroethane production	kt	2,683	3,014	3,346	3,639	3,511	3,517	3,243	3,213	3,155	2,841	2,558	2,733	2,730

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the CO_2 and CH_4 emission factors for 1,2-dichloroethane production, the default values of -50 - +20% and -11 - +11% in the *2006 IPCC Guidelines* were respectively applied. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of 1,2-dichloroethane production was estimated as -50 - +21% and -12 - +12%, respectively.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CH_4 emissions from 1,2-Dichloroethane production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

For CH_4, updates to the statistics resulted in recalculations for 2013. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.4. Ethylene oxide Production (2.B.8.-)

a) Category Description

1) CO_2, CH_4

Ethylene oxide is produced by reacting ethylene with oxygen over a catalyst, with CO_2 released as a by-product. (See below) There are two methods in providing oxygen; one through providing air, and the other through providing pure oxygen separated from air.

$$C_2H_4 + 0.5O_2 \rightarrow C_2H_4O$$
$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

The CO_2 emitted is partially vented into the atmosphere, and is partially recovered by a carbonate solution to be used in food and beverage production etc.

Generally, ethylene oxide production is a process where gases are recycled, and therefore it is necessary to partially purge the gases out of the system so to suppress the rise in pressure due to the accumulation of non- reactive fine impurities (such as argon or nitrogen) contained in the raw material gas, which results in gas emissions. This contains gases such as ethylene, methane, oxygen, or argon, and are generally flared as they are, but CH_4 may be emitted through leakage or venting.

b) Methodological Issues

- ***Estimation Method***

➢ ***CO_2***

Following the Tier 3 method of the *2006 IPCC Guidelines*, emissions are estimated by multiplying the total domestic production amount by a country-specific emission factor established based on factory-specific data. The difference between emissions estimated using an EF which does not reflect recovery, and emissions estimated using an EF which reflects recovery (the actual EF used for this sub-category) is reported under CO_2 from carbonated gas and dry ice production (2.H.2). (See below)

$$E_{CO_2} = EO * EF_1$$

$E_{CO2:}$ CO_2 emissions from ethylene oxide production
EO: Ethylene oxide production amount per year
EF_1: CO_2 emissions per ethylene oxide production amount (reflecting recovery)

$$R_{CO_2} = EO * EF_2 - E_{CO_2}$$

R_{CO2}: CO_2 recovery amount from ethylene oxide production processes
EO: Ethylene oxide production amount per year
EF_2: CO_2 emissions per ethylene oxide production amount (without reflecting recovery)

➢ ***CH_4***

Following the Tier 1 method of the *2006 IPCC Guidelines*, emissions are estimated by multiplying the total domestic production amount by a country-specific emission factor established based on factory-specific data.

- ***Emission Factors***

  - ***CO_2***

EFs per production amount (recovery reflected: 0.24 t-CO_2/t, recovery not reflected: 0.33 t-CO_2/t) are used. (provided by the Japan Petrochemical Industry Association) The EFs are a simple average of factory-specific EFs for all factories in Japan, and are based on the carbon balance etc of the amounts of raw or secondary material input, and amounts of product or by-product output. The production amounts per factory are confidential, and therefore a weighted average cannot be taken. Additionally, since all ethylene oxide is produced by the same process (the Oxygen method), it is considered that a simple average would not divert far from the actual conditions. In the Oxygen method applied in Japan, the selectivity of the catalyst is higher than that of the default, and therefore the EF not reflecting recovery is lower than the default value of 0.663 t-CO_2/t.

  - ***CH_4***

An EF based on measured data and specific to the manufacturer is used. The CH_4 emission data used to establish the EF is estimated by the manufacturer based on an estimation of CH_4 emissions into the atmosphere, which is further based on the CH_4 amount in the gas introduced from outside when gases are purged from the process. Data are only available from 2004, and therefore for the preceding years, a three-year average of data from 2004 to 2006 will be taken and applied. The data is confidential.

- ***Activity Data***

  - ***CO_2***

The ethylene oxide production amounts in the *Yearbook of Current Production Statistics - Chemical Industry* (METI) are used. (Table 4-26)

Table 4-26 Ethylene oxide production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Ethylene oxide production	kt	714	795	961	1,001	972	957	795	792	843	842	849	915	894

  - ***CH_4***

The ethylene oxide production amount at the one manufacturer is used. The data is confidential.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty for the CO_2 emission factor, the default value of 10% in the *2006 IPCC Guidelines* was applied. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated at 11%.

For the uncertainty for the CH_4 emission factor, the default value of 60% in the *2006 IPCC Guidelines* was applied. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated at 60%.

- ***Time-series Consistency***

For activity data, the same source – the *Yearbook of Current Production Statistics - Chemical Industry* (METI) and data from one manufacturer are used throughout the time series. The emission factor is set based on data from the same sources. Therefore, CO_2 and CH_4 emissions from ethylene oxide production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.5. Acrylonitrile Production (2.B.8.-)

a) Category Description

1) CO_2

Acrylonitrile (C_3H_3N) is used as raw material for acrylic fiber or synthetic resin, and is mainly manufactured by way of direct ammoxidation of propylene with ammonia and oxygen over a metal catalyst. (SOHIO process) On the order of 85 percent of the propylene feedstock is converted to either the primary product acrylonitrile or secondary products acetonitrile or hydrogen cyanide. (See below chemical equations 1 to 3) The remainder of the propylene feedstock is either converted to other hydrocarbons through side reactions in the ammoxidation process or converted directly to CO_2 by direct oxidation of the feedstock in the ammoxidation process (See below chemical equation 4)

Equation 1: Acrylonitrile reaction

$$CH_2 = CHCH_3 + 1.5O_2 + NH_3 \rightarrow CH_2 = CHCN + 3H_2O$$

Equation 2: Hydrogen cyanide reaction

$$CH_2 = CHCH_3 + 3O_2 + 3NH_3 \rightarrow 3HCN + 6H_2O$$

Equation 3: Acetonitrile reaction

$$CH_2 = CHCH_3 + 1.5O_2 + 1.5NH_3 \rightarrow 1.5CH_3CN + 3H_2O$$

Equation 4: Feedstock oxidation

$$CH_2 = CHCH_3 + 4.5O_2 \rightarrow 3CO_2 + 3H_2O$$

2) CH_4

The CH_4 off-gases are analyzed in the plants manufacturing acrylonitrile, but since no emissions are detected, they are reported as NA.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated by multiplying the acrylonitrile production amount by Japan's country-specific emission factor, based on plant-specific data, in accordance with the Tier 3 method in the *2006 IPCC Guidelines*.

- ***Emission Factors***

A CO_2 emission factor per production (0.73 t-CO_2/t, provided by the Japan Petrochemical Industry

Association) is applied for all years. This emission factor is an arithmetic mean of plant-specific CO_2 emission factors for all plants, based on the carbon balance of raw material and secondary material input and product and by-product output for each plant. This is done due to the fact that production data for each plant are confidential and this does not allow for taking a weighted average, and that acrylonitrile is manufactured by the same process throughout Japan (SOHIO process), which means that taking an arithmetic mean will not deviate far from actual conditions.

In the acrylonitrile manufacturing processes in Japan, acetonitrile and hydrogen cyanide are collected as products, and therefore the emission factor is close to the default value in the *2006 IPCC Guidelines* (0.79 t-CO_2/t). The reason for it being slightly lower is due to efforts made to improve the efficiency of production.

- ***Activity Data***

Acrylonitrile production amounts given in the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used for activity data.

Table 4-27 Acrylonitrile production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Acrylonitrile production	kt	602	652	734	697	699	713	563	631	718	665	553	499	468

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, the default value of 60% in the *2006 IPCC Guidelines* was used. For the uncertainty of activity data, the default value of 5% in the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated at 60%.

- ***Time-series Consistency***

For activity data, the same source, the *Yearbook of Chemical Industries Statistics*, are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CO_2 emissions from acrylonitrile production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.6. Carbon Black Production (2.B.8.-)

a) Category Description

1) CO_2, CH_4

Carbon black is mainly is produced from the partial combustion of byproduct oil and gas from the petroleum refining and metallurgical refining processes in a high temperature atmosphere. (furnace black process) The CO_2 and CH_4 in the tail gas (offgas) emitted from the carbon black production

process is released into the atmosphere.

b) Methodological Issues

- ***Estimation Method***

  - ***CO_2***

CO_2 emissions from carbon black production are calculated by multiplying the carbon black production amount by Japan's country-specific emission factor, in accordance with the Tier 1 method in the *2006 IPCC Guidelines*.

  - ***CH_4***

CH_4 emissions from carbon black production are calculated by multiplying the carbon black production amount by Japan's country-specific emission factor, established based on plant-specific data, in accordance with the Tier 1 method in the *2006 IPCC Guidelines*.

- ***Emission Factors***

  - ***CO_2***

Since it is considered that the CO_2 from natural gas that is used to heat the furnace (secondary feedstock origin) is already accounted for under fuel combustion (1.A.), only CO_2 from the oil and gas used directly as raw material (primary feedstock origin) is accounted for here. A CO_2 emission factor per production (2.06 tCO_2/t) provided by the Carbon Black Association is used. This is established by taking a weighted average of total CO_2 measurements (subtracting out the carbon left over in the product from the carbon in the raw material, then dividing it by the weight of the product) for all five member companies' plants, with the production amounts of each company. Since these five companies cover over 95% of domestic production and sales, the emission factor is considered representative for Japan. All companies use the oil furnace process, and therefore emission factors do not differ much nor vary much annually.

  - ***CH_4***

In carbon black manufacturing plants in Japan, CH_4 is only emitted into the atmosphere during non-steady operation, when venting is done at shutdowns and startups. According to the Carbon Black Handbook (Carbon Black Association), the concentrations of CH_4, and the concentrations of CO, CO_2, and CH_4 combined in the average tail gas is 0.6wt% and 21.5wt% respectively, and this is the same for during shutdowns and startups. Therefore, the CH_4 emission factor can be calculated from the CO_2 emission factor (2.06 t-CO_2/t) as the below. The data is confidential.

$$EF_{CH_4} = 2.06\mathrm{tCO_2/t} * R * \frac{0.6\mathrm{wt\%}}{21.5\mathrm{wt\%}} * \frac{16}{44}$$

R: The ratio of venting time at shutdowns and startups to the total operation time

No gas leakage occurs from the system, since inside the process the air pressure is negative, and therefore only emissions associated with venting is estimated.

- ***Activity Data***

Carbon black production amounts given in the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used for activity data for both CO_2 and CH_4 emissions associated with the manufacturing of carbon black.

Table 4-28 Carbon black production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Carbon black production	kt	793	759	772	805	832	841	725	635	730	670	612	628	609

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty for the emission factor for carbon black was calculated by finding the 95% confidence interval of emission factors. The estimated uncertainty was 55% for both CO_2 and CH_4. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used for both CO_2 and CH_4. As a result, the uncertainty of carbon black production emissions was estimated at 55% for both CO_2 and CH_4.

- ***Time-series Consistency***

For activity data, the same source, the *Yearbook of Chemical Industries Statistics*, are used throughout the time series. The emission factor is constant throughout the time series. Therefore, emissions have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

For both CO_2 and CH_4, updates to the statistics resulted in recalculations for 2013. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.7. Styrene Production (2.B.8.-)

a) Category Description

CH_4 is emitted in the styrene production process.

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from styrene production were calculated by multiplying styrene production amount by Japan's country-specific emission factor, based on the method given in the *2006 IPCC Guidelines*.

- ***Emission Factors***

Estimates of amount of exhaust gas from flare stacks at a normal operation and an unsteady operation at operating sites in Japan (assuming that 98% of the amount that enters is combusted[4]), and measured amount of waste gas from heating furnaces, were divided by the production amount to calculate emission factors for each company. The weighted average by production from each company was then applied to establish the emission factor. (Surveyed by the Japan Petrochemical Industry Association) This emission factor is confidential.

[4] See footnote 1.

- ***Activity Data***

Styrene monomer production amounts from the *Yearbook of Chemical Industries Statistics* compiled by the Ministry of Economy, Trade and Industry were used as activity data for CH_4 emissions from styrene production.

Table 4-29 Styrene monomer production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Styrene production	kt	2,227	2,952	3,020	3,375	3,373	3,417	2,699	3,043	3,019	2,594	2,426	2,539	2,518

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty for the CH_4 emission factor for styrene production was estimated by finding the 95% confidence interval of emission factors. The estimated uncertainty was 113%. For the uncertainty of activity data, the standard value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated as 113%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CH_4 emissions from styrene production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Updates to the statistics resulted in recalculations for 2013. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.8. Phthalic anhydride Production (2.B.8.-)

a) Category Description

Phthalic anhydride is used as raw material for plasticizers, synthetic resins, paints, dyes etc. CO and CO_2 are emitted during the oxidation of naphthalene and o-xylene in the production process of Phthalic anhydride. CO is also combusted and ultimately emitted as CO_2.

b) Methodological Issues

- ***Estimation Method***

The production amount of phthalic anhydride is multiplied by an emission factor per production amount to calculate emissions.

- ***Emission Factors***

The CO_2 generation rate (mol %) was calculated by assuming that carbon that did not become products or other by-products ultimately become CO_2, and by using the yield of products or other by-products (mol %) per production process of phthalic anhydride (*Petrochemical Processes* (The

Japan Petroleum Institute)) The EFs in each production process are calculated from the CO_2 emissions per production amount, based on the generation rate of CO_2 and products and the molecular weight of each substance. The yield is shown with an upper limit and lower limit in *Petrochemical Processes* (The Japan Petroleum Institute), and therefore EFs are set using the median value.

Table 4-30 Generation rate of each substance by production process of phthalic anhydride

Production process	Product yield [mol %]	Maleic Anhydride [mol %]	Other [mol %]	CO_2 * [mol %]	EF * [t-CO_2/t]
Oxidation of naphthalene	87-91	3-5	1	2-8	0.19
Oxidation of o-xylene	80-83	4-6	1-2	10-16	0.54

Source: Petrochemical Processes (The Japan Petroleum Institute) (excluding*)

Following this, a weighted average is taken for each year to set the EF for all of Japan. This is based on the productive capacity by year and by production process in the Chemicals Handbook (The Heavy and Chemical Industries News Agency)

Table 4-31 The weighted average EF based on productive capacity of phthalic anhydride

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Weighted average EF	t-CO_2/t	0.39	0.39	0.41	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37

No information is available on the productive capacity per production process prior to 1996, and therefore the 1996 value is used for the preceding years.

- ***Activity Data***

The production amounts of phthalic anhydride in *The Yearbook of Current Production Statistics - Chemical Industry* (Ministry of Economy, Industry and Trade) are used.

Table 4-32 Phthalic anhydride production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Phthalic anhydride production	kt	300	319	288	216	177	181	159	137	160	148	162	158	156

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, a 32% value, derived from the upper/lower limits of the theoretical value of the yield which was used to establish the emissions factor, was used. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated at 32%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is based on a consistent methodology throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Updates to the statistics resulted in recalculations for 2013. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.9. Maleic anhydride Production (2.B.8.-)

a) Category Description

Maleic anhydride is used as raw material for unsaturated polyester resins, or for resin improving agents, food additives, pharmaceutical ingredients, or synthetic raw material for organic acids such as malic acid and succinic acid. CO and CO_2 are emitted during the oxidation of benzene and n-butane in the production process of maleic anhydride. CO is also combusted and ultimately emitted as CO_2.

b) Methodological Issues

- ***Estimation Method***

The production amount of maleic anhydride is multiplied by an emission factor per production amount to calculate emissions.

- ***Emission Factors***

The CO_2 generation rate (mol %) was calculated by assuming that carbon that did not become products or other by-products ultimately become CO_2, and by using the yield of products or other by-products (mol %) per production process of maleic anhydride (*Petrochemical Processes* (The Japan Petroleum Institute)) The EFs in each production process are calculated from the CO_2 emissions per production amount, based on the generation rate of CO_2 and products and the molecular weight of each substance. The yield is shown with an upper limit and lower limit in *Petrochemical Processes* (The Japan Petroleum Institute), and therefore EFs are set using the median value.

Table 4-33 Generation rate of each substance by production process of maleic anhydride

Production process	Product yield [mol %]	Maleic Anhydride [mol %]	Other [mol %]	CO_2 * [mol %] *	EF * [t-CO_2/t]
Oxidation of benzene	70-80	-	-	20-30	0.74
Oxidation of n-butane	55-60	-	-	40-45	1.65

Source: Petrochemical Processes (The Japan Petroleum Institute) (excluding *)

Following this, a weighted average is taken for each year to set the EF for all of Japan. This is based on the productive capacity by year and by production process in the Chemicals Handbook (The Heavy and Chemical Industries News Agency)

Table 4-34 The weighted average EF based on productive capacity of maleic anhydride

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Weighted average EF	t-CO_2/t	1.20	1.20	1.23	1.11	1.11	1.11	1.11	1.11	1.11	1.04	1.04	1.04	1.04

No information is available on the productive capacity per production process prior to 1996, and therefore the 1996 value is used for the preceding years.

- ***Activity Data***

The production amounts of maleic anhydride in *The Yearbook of Current Production Statistics - Chemical Industry* (Ministry of Economy, Industry and Trade) are used.

Table 4-35 Maleic anhydride production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Maleic anhydride production	kt	103	116	132	103	106	104	86	85	93	88	75	86	85

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, a 16% value, derived from the upper/lower limits of the theoretical value of the yield which was used to establish the emissions factor, was used. For the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty of emissions was estimated at 17%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is based on a consistent methodology throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.8.10. Hydrogen Production (2.B.8.-)

a) Category Description

CO_2 is emitted from the steam reforming process of fossil fuels such as natural gas, petroleum, etc during hydrogen production. Hydrogen is produced as a by-product during petroleum refining, ethylene production, etc, and is recovered and used, however relevant emissions are already captured under other categories. Therefore, CO_2 generated from hydrogen production from raw materials, where the sole purpose is to obtain hydrogen, is addressed here.

b) Methodological Issues

- ***Estimation Method***

The production amount of hydrogen is multiplied by an emission factor per production amount to calculate emissions.

- ***Emission Factors***

The aggregated CO_2 emissions from industrial gas producers was divided by the aggregated production amounts of hydrogen to establish a CO_2 EF per production. Both aggregated values are based on values reported by member companies of the Japan Industrial and Medical Gases Association.

Table 4-36 EFs for hydrogen production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EF	t-CO_2/10^3Nm^3	0.44	0.71	0.76	0.80	0.77	0.78	0.79	0.79	0.79	0.79	0.79	0.78	0.76

- ***Activity Data***

The production amounts of hydrogen are for those processes that entail CO_2 emissions, and are based on values reported by member companies of the Japan Industrial and Medical Gases Association.

Table 4-37 Hydrogen production amount

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Hydrogen production	10^3Nm^3	7,431	25,185	46,706	38,027	37,389	36,212	34,438	36,387	39,023	37,544	34,944	32,248	28,476

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty value of 77% for ethylene production was used for the EF uncertainty. Similarly, for the uncertainty of activity data, the default value of 5% given by the *2006 IPCC Guidelines* was used. As a result, the uncertainty for CO_2 emissions from hydrogen production was estimated as 77%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is based on a consistent methodology throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Not applicable.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.9. Fluorochemical Production (2.B.9.)

4.3.9.1. By-product Emissions: Production of HCFC-22 (2.B.9.-.)

a) Category Description

HFC-23 is generated as a by-product of HCFC-22 production.

b) Methodological Issues

- ***Estimation Method***

Estimating emissions involved subtracting the recovery and destruction amount of by-product HFC-23 (measured data) from the amount of by-product HFC-23 generated at HCFC-22 production plants in Japan. The amount of by-product HFC-23 was estimated by multiplying the production of HCFC-22 by the generation rate of HFC-23 (obtained from the results of composition analysis of the interior of a reactor). Emission factors are country-specific.

The recovery/destruction units are constantly running when the plants are in operation. If any trouble arises in the units, management practices are to stop the plant operation, and for any portion of emissions without recovery/destruction, this is reflected in the data.

Emissions of by-product HFC-23 associated with the production of HCFC-22

Emissions of HFC-23 = Production of HCFC-22 [t] ×Rate of generation of HFC-23 [%]
- Amount of recovery and destruction [t]

Table 4-38 Indices related to By-product Emissions of HFC-23: Production of HCFC-22

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Production of HCFC-22	t	60,122	81,000	95,271	65,715	65,905	61,197	60,401	26,682	46,149	45,314	54,388	47,546	51,753
Rate of generation of HFC-23	%	2.13%	2.13%	1.70%	1.90%	1.94%	1.82%	2.00%	2.34%	2.01%	1.53%	1.60%	1.41%	1.46%
Emission rate to production of HCFC-22	%	1.79%	1.79%	1.11%	0.06%	0.09%	0.03%	0.07%	0.01%	0.01%	0.002%	0.002%	0.002%	0.003%
Emissions	t	1,076	1,450	1,060	40	56	19	40	3	4	1	1	1	2
	Mt-CO_2 eq.	15.93	21.46	15.69	0.59	0.83	0.28	0.59	0.05	0.05	0.02	0.02	0.02	0.02

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* Emissions decreased because all manufacturing facilities were equipped with recovery/destruction units in 2004. The low emission rate to production is due to efforts made in preventing the fall of the operating rates through the improvement in techniques of operation management of destruction facilities and maintenance. Emission reduction has further advanced since, with continuous efforts made in improvement of operation management techniques etc.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using the combined HCFC-22 production amounts for the purpose of material for fluorocarbon polymers (estimated from the production amounts of fluorocarbon polymers and the ratio of HCFC-22 production amounts for the purpose of material for fluorocarbon polymers to the production amounts of fluorocarbon polymers (an average of 1995-2006 where data were available)) and HCFC-22 production amounts for the purpose of refrigerants (estimated from total HCFC-22 shipment amounts[5], and HCFC-22 shipment amounts for the purpose of refrigerants from 1995) as data for total HCFC-22 production amounts, and by using data on the emission rate to the production of HCFC-22 from 1995, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emissions, a 2% value from the *2006 IPCC Guidelines* was applied.

- ***Time-series Consistency***

For years after 1995, the Manufacturing Industries Sub-Group, Ministry of Economy, Trade and Industry annually collects and estimates F-gas emissions. For the years 1990 to 1994, estimates have been done by extrapolation etc of relevant data from 1995 onward, and therefore time-series consistency is taken into account to the extent possible.

d) Category-specific QA/QC and Verification

The data collected and estimated by the Manufacturing Industries Sub-Group, Ministry of Economy, Trade and Industry, is checked by the Committee for Greenhouse Gas Estimation Methods and is used in the inventory. Emissions are surveyed for all production plants in Japan. Composition analysis is carried out frequently, as in the case where one plant takes measurements every day. Concentration measurements are implemented at the vent of the plant.

e) Category-specific Recalculations

There have been no source-specific recalculations.

[5] MITI Documents of the first meeting of the Group for global warming chemicals, Risk Management Sub-Group, Chemicals Council, 1997.

f) Category-specific Planned Improvements

No improvements are planned.

4.3.9.2. Fugitive Emissions (2.B.9.-.)

a) Category Description

HFCs, PFCs, SF_6, and NF_3 are emitted as fugitive emissions during manufacturing. Regarding returned gas cylinders, when residual gas is decomposed and the containment shell is cleansed, or when there is release into the atmosphere, these emissions are reported under this subcategory.

b) Methodological Issues

- ***Estimation Method***

Emissions were reported based on measurement data at each of HFCs, PFCs, SF_6, and NF_3 manufacturing plant in Japan. Recovery etc is hereby taken into account. The recovery/destruction units are constantly running when the plants are in operation. If any trouble arises in the units, management practices are to stop the plant operation.

The associated indices are given in the table below.

Table 4-39 Fugitive emissions from HFC production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Emissions	Mt-CO_2 eq.	0.0015	0.5590	0.2962	0.4494	0.3666	0.3567	0.3065	0.2338	0.1281	0.1513	0.1205	0.1312	0.1006

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry (data from Japan Fluorocarbon Manufactures Association), and data provided by the Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* With emission reduction measures such as installation of destruction units subsidized by the government, and re-evaluation of the production processes, emission reduction has advanced.

Table 4-40 Indices related to fugitive emissions from PFC production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Emissions	Mt-CO_2 eq.	0.331	0.914	1.661	1.041	1.091	0.977	0.649	0.459	0.248	0.206	0.148	0.111	0.107

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry (data from Japan Chemical Industry Association), Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* With emission reduction measures such as installation of destruction units subsidized by the government, and re-evaluation of the production processes, emission reduction has advanced. The installation of destruction units in 2011 for lean gas emitted further contributed to the achievement of emission reduction.

Table 4-41 Indices related to fugitive emissions from SF_6 production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Production of SF_6	t	1,848	2,392	1,556	2,313	2,787	2,723	2,647	2,562	2,201	1,993	2,230	2,128	1,997
Emissions	t	152.2	197.0	36.0	40.8	57.2	50.2	53.9	10.2	8.3	5.8	5.4	4.1	2.7
	Mt-CO_2 eq.	3.471	4.492	0.821	0.930	1.303	1.144	1.229	0.233	0.189	0.132	0.123	0.093	0.062

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry (data from Japan Chemical Industry Association), Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* Emissions decreased because all manufacturing facilities were equipped with recovery/destruction units in 2009. Re-evaluation of the production processes, and handling at shipment has also advanced emission reduction.

Table 4-42 Indices related to fugitive emissions from NF_3 production

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Production of NF_3	t	6	37	208	1,663	2,390	3,028	3,353	2,898	3,648	3,614	3,507	4,153	4,660
Emissions	t	0.2	1.1	1.2	59.2	47.4	49.5	53.2	55.9	67.0	79.2	61.5	71.5	39.1
	Mt-CO_2 eq.	0.003	0.019	0.021	1.018	0.815	0.851	0.915	0.961	1.152	1.362	1.058	1.230	0.673

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry (data from Japan Chemical Industry Association)

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using HFC, PFC, SF_6, and NF_3 shipment amounts[6] which is thought to be proportional to HFC, PFC, SF_6, and NF_3 production amounts, and the ratio of emissions to the HFC, PFC, SF_6, and NF_3 production amounts from 1995, and weighted average GWPs for HFCs and PFCs from 1995, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emissions for all HFCs, PFCs, SF_6, and NF_3, a 2% value from the *2006 IPCC Guidelines* was applied.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.4. Metal Industry (2.C.)

This category covers CO_2, CH_4, HFC, PFC and SF_6 emissions from the manufacturing processes of metal products.

This section includes GHG emissions from the following sources: Iron and steel production (2.C.1.), Ferroalloys production (2.C.2.), Aluminum production (2.C.3.), Magnesium production (2.C.4.), Lead production (2.C.5.), and Zinc production (2.C.6.).

In 2014, emissions from Metal production were 6,338 kt-CO_2 eq. and represented 0.5% of Japan's total GHG emissions (excluding LULUCF). The total emissions of CO_2 and CH_4 from this category had decreased by 15.7% compared to 1990. The total of HFCs, PFCs and SF_6 had decreased by 47.0% compared to 1990.

[6] MITI Documents of the first meeting of the Group for global warming chemicals, Risk Management Sub-Group, Chemicals Council, 1997. All further reference to 'shipment amounts' used for emission estimates for years 1990 to 1994 are from the same source.

Table 4-43 Emissions from 2.C. Metal Industry

Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	2.C Metal Production	2.C.1	Iron and steel production	Use of electric arc furnaces in steel production	kt-CO_2	385	357	201	242	178	212	156	112	160	162	174	133	146
				Limestone and dolomite use in iron and steel production	kt-CO_2	6,888	6,492	6,538	6,255	6,390	6,483	6,081	5,356	5,941	5,803	5,887	6,037	5,988
CH_4	2.C Metal Production	2.C.1	Iron and steel production	Use of electric arc furnaces in steel production	kt-CH_4	0.74	0.72	0.67	0.68	0.70	0.71	0.61	0.51	0.59	0.60	0.59	0.60	0.59
		2.C.2	Ferroalloys production		kt-CH_4	0.19	0.14	0.13	0.13	0.11	0.11	0.11	0.11	0.12	0.11	0.13	0.13	0.12
	Total				kt-CH_4	0.92	0.85	0.80	0.80	0.82	0.82	0.72	0.62	0.71	0.72	0.72	0.73	0.71
	Total				kt-CO_2 eq.	23	21	20	20	20	21	18	15	18	18	18	18	18
Total of CO_2 and CH_4					kt-CO_2 eq.	7,296	6,871	6,760	6,517	6,588	6,716	6,254	5,484	6,118	5,983	6,079	6,188	6,152
Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFCs	2.C Metal Production	2.C.4	Magnesium production		kt-CO_2 eq.	NO	NO	NO	NO	NO	NO	NO	NO	NO	1.00	1.29	1.29	1.29
PFCs	2.C Metal Production	2.C.3	Aluminium production		kt-CO_2 eq.	203.66	103.55	26.41	21.76	21.81	21.62	21.59	16.22	15.28	15.24	13.27	9.59	1.91
SF_6	2.C Metal Production	2.C.4	Magnesium production		t	6.43	5.00	43.00	48.42	45.65	45.58	27.30	10.00	12.88	8.00	8.00	7.00	8.00
					kt-CO_2 eq.	146.54	114.00	980.40	1,104.05	1,040.87	1,039.20	622.44	228.00	293.73	182.40	182.40	159.60	182.40
Total of F-gases					kt-CO_2 eq.	350.20	217.55	1,006.81	1,125.80	1,062.68	1,060.83	644.03	244.22	309.01	198.65	196.95	170.48	185.60

4.4.1. Iron and Steel Production (2.C.1.)

4.4.1.1. Steel Production (2.C.1.a)

1) CO_2

Coke oxidizes when it is used as a reduction agent in steel production, and CO_2 is generated. The amount of coke used has been included under consumption of fuel in the Fuel Combustion Sector (1.A.), and the CO_2 generated through the oxidization of coke used as a reducing agent has already been calculated under Fuel Combustion Sector (1.A.). Therefore, it has been reported as “IE”.

4.4.1.2. Pig Iron Production (2.C.1.b)

1) CO_2

CO_2 generated from pig iron production is emitted when coke is used as a reduction agent. The amount of coke used has been included under consumption of fuel in the Fuel Combustion Sector (1.A.), and the CO_2 generated through the oxidization of coke used as a reducing agent has already been calculated under Fuel Combustion Sector (1.A.). Therefore, it has been reported as “IE”.

2) CH_4

It is theoretically impossible for CH_4 generation in association with pig iron production, and it has been confirmed that CH_4 is not emitted from actual measurements. Therefore, emissions have been reported as “NA”.

4.4.1.3. Direct reduced iron production (2.C.1.c)

1) CO_2

CO_2 is generated during the production of direct reduced iron, through the oxidation of natural gas or coal used as reductants. The amount of natural gas or coal used has been included under consumption of fuel in the Fuel Combustion Sector (1.A.), and the CO_2 generated through the oxidization of natural gas or coal used as reducing agents are already been calculated under Fuel Combustion Sector (1.A.). Therefore, it has been reported as “IE”.

2) CH_4

CH_4 generated when making direct reduced iron is generated by the combustion of natural gas or coal; these emissions come under the Fuel Combustion Sector (1.A.). As they are already calculated in this sector, they are reported as "IE".

4.4.1.4. Sinter Production (2.C.1.d)

1) CO_2

CO_2 generated when making sinter is all generated by the combustion of coke fines; these emissions come under the Fuel combustion sector (1.A.). As they are already calculated in this 1.A. sector, they are reported as "IE".

CO_2 emissions from limestone and dolomite used when making sinter are counted under "4.4.1.7. Limestone and dolomite use in Iron and Steel Production".

2) CH_4

CH_4 generated when making sinter is all generated by the combustion of coke fines; these emissions come under the Fuel Combustion Sector (1.A.). As they are already calculated in this sector, they are reported as "IE".

4.4.1.5. Pellet Production (2.C.1.e)

1) CO_2

CO_2 generated when making pellets is generated by the combustion of fine ore; these emissions come under the Fuel combustion sector (1.A.). As they are already calculated in this 1.A. sector, they are reported as "IE".

CO_2 emissions from limestone and dolomite used when making pellets are counted under "4.4.1.7. Limestone and dolomite use in Iron and Steel Production".

2) CH_4

CH_4 generated when making pellets is generated by the combustion of fine ore; these emissions come under the Fuel Combustion Sector (1.A.). As they are already calculated in this sector, they are reported as "IE".

CO_2 emissions from limestone and dolomite used when making pellets are counted under "4.4.1.7. Limestone and dolomite use in Iron and Steel Production".

4.4.1.6. Use of Electric Arc Furnaces in Steel Production (2.C.1.-)

a) Category Description

CO_2 is emitted from carbon electrodes when using electric arc furnaces to make steel. CH_4 is also emitted from electric arc furnaces during iron and steel production.

b) Methodological Issues

1) CO_2

- **Estimation Method**

CO_2 emissions from arc furnaces for steel production are estimated by amount of carbon calculated by weight of production and import of carbon electrodes minus weight of export of carbon electrodes. This difference of the carbon is assumed to be diffused to the atmosphere as CO_2. The carbon included in electric furnaces gas given in the *General Energy Statistics* are subtracted from the CO_2 emission in this source since these emissions are included in category 1.A fuel combustion.

- **Activity Data**

Production of carbon electrodes given in *Yearbook of Ceramics and Building Materials Statistics* compiled by the Ministry of Economy, Trade and Industry, and import and export of carbon electrodes given in *Trade Statistics of Japan*, Ministry of Finance are used.

Table 4-44 CO_2 emissions from carbon electrodes of furnaces

	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
#A Import	t	12,341	18,463	11,363	15,075	13,893	15,035	15,116	11,218	17,321	20,436	20,027	19,960	19,226
#B Domestic production	t	211,933	186,143	184,728	216,061	221,112	229,734	201,256	169,545	205,081	217,847	197,278	180,322	180,555
#C Export	t	87,108	92,812	107,998	138,409	149,330	150,491	134,509	116,489	139,757	154,204	135,863	128,435	121,079
#D Electric furnaces gas	t	32,188	14,300	33,201	26,747	37,217	36,415	39,349	33,709	39,017	39,949	33,898	35,553	38,770
Domestic consumptions (#A + #B - #C - #D)	t	104,978	97,493	54,892	65,981	48,458	57,864	42,514	30,564	43,629	44,130	47,544	36,293	39,932
CO_2 emissions	kt-CO_2 eq.	385	357	201	242	178	212	156	112	160	162	174	133	146

2) CH_4

- **Estimation Method**

Emissions were calculated by multiplying an emission factor based on actual measurements obtained in Japan by the energy consumption of electric arc furnaces. This is the same method used for calculating CH_4 emissions in the Fuel Combustion Sector (1.A. Stationary sources).

- **Emission Factors**

The emission factor of energy consumption of electric arc furnaces (12.8 kg-CH_4/TJ) was determined by using the data from actual measurement surveys. (See Chapter 3, 3.2.5. and Chapter 4, 4.3.5.1)

- **Activity Data**

Energy consumption amounts included in the "electric furnace" category for the iron and steel industries of the *General Energy Statistics* were used.

Table 4-45 Energy consumption in electric arc furnaces

Electricity consumption	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Electric furnaces	TJ	57,564	55,986	52,457	52,747	55,051	55,687	47,316	39,753	45,793	47,185	46,459	47,100	46,156

c) Uncertainties and Time-series Consistency

1) CO_2

- **Uncertainty**

Because all CO_2 from electric arc furnaces are assumed to escape into the atmosphere, no emission factor has been set. Therefore, by assessing the uncertainty for activity data the uncertainty for emissions is assessed. As a result of combining the uncertainties of the parameters for activity data, the uncertainty was estimated as 5%.

- ***Time-series Consistency***

For activity data (emissions), the same sources are used throughout the time series. Therefore, CO_2 emissions from electric arc furnaces have been estimated in a consistent manner throughout the time-series.

2) CH_4

- ***Uncertainty***

The uncertainty for the emission factor has been estimated as 163% and the uncertainty for activity data has been estimated as 5% (see chapter 3). As a result, the uncertainty for CH_4 emissions has been estimated as 163%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CH_4 emissions from electric arc furnaces in steel production have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations were conducted for 2013 CH_4 emissions, since the value of the energy consumption in electric arc furnaces was updated in the *General Energy Statistics*. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.4.1.7. Limestone and dolomite use in Iron and Steel Production (2.C.1.-)

a) Category Description

Limestone contains $CaCO_3$ and minute amounts of $MgCO_3$, and dolomite contains $CaCO_3$ and $MgCO_3$. The heating of limestone and dolomite releases CO_2 derived from $CaCO_3$ and $MgCO_3$.

b) Methodological Issues

- ***Estimation Method***

The amounts of limestone and dolomite used in iron and steel production are multiplied by the emission factors to calculate emissions.

- ***Emission Factors***

➢ ***Limestone***

The emission factor (440 [kg-CO_2/t]) is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from limestone (55.4%, the median value of the "54.8% to 56.0%" given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from limestone (0.5%, the median value of the "0.0% to 1.0%" given in The Story of Lime [Japan Lime Association]). The emission factor is

country-specific. (See 4.2.3. b) for details)

➢ ***Dolomite***

The emission factor (471 [kg-CO_2/t]) is calculated by adding the value obtained when multiplying the molecular weight ratio of CO_2 and $CaCO_3$ by the percentage of CaO that can be extracted from dolomite (34.5%, the median value of the 33.1% to 35.85% range given in The Story of Lime [Japan Lime Association]) and the value obtained when multiplying the molecular weight ratio of CO_2 and $MgCO_3$ by the percentage of MgO that can be extracted from dolomite (18.3%, the median value of the 17.2% to 19.5% range given in The Story of Lime [Japan Lime Association]). The emission factor is country-specific. (See 4.2.3. b) for details)

● ***Activity Data***

Of the limestone and dolomite consumption data in the Adjusted Price Transaction Table, all limestone and dolomite consumption categorized under 'emissive use' that are under the Iron and steel/Refining related sectors will be accounted for under this subcategory. Activity data is in dry weight, converted using the water content from limestone used for cement.

The corresponding sectors in the Adjusted Price Transaction Table are as follows:

Table 4-46 Corresponding sectors in the Adjusted Price Transaction Table

Uses	Corresponding sectors in the Adjusted Price Transaction Table (Limestone)	Corresponding sectors in the Adjusted Price Transaction Table (Dolomite)
Iron and steel/Refining	2611-01 Steel - pig iron to 2611-04 Steel - crude ore (electric furnace)	2611-01 Steel - pig iron to 2631-03 Steel - cast and forged materials (iron)
	2631-02 Steel - cast iron pipe, -03 cast and forged materials (iron)	
	2711-01 Non-ferrous metal - copper, -02 lead and zinc	2711-02 Non-ferrous metal - lead and zinc
	2722-03 Non-ferrous metal - non-ferrous metal cast and forged products	

Note: The numbers before the sector names are categorization numbers in the Adjusted Price Transaction Table.

Table 4-47 Amounts of limestone and dolomite consumption

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Limestone consumption														
For Steel and Refinement (dry)	kt	14,430	13,590	13,619	12,577	12,777	12,873	12,177	11,000	11,815	11,541	11,663	11,878	11,757
Dolomite consumption														
For Steel and Refinement (dry)	kt	1,144	1,089	1,160	1,530	1,631	1,739	1,535	1,096	1,576	1,539	1,603	1,720	1,731

c) Uncertainties and Time-series Consistency

● ***Uncertainty***

For the uncertainty of emission factors, a 3% default value in the *2006 IPCC Guidelines* was used for both limestone and dolomite. For the uncertainty for activity data, a 3% default value in the *2006 IPCC Guidelines* was used for both limestone and dolomite. As a result, the uncertainty for emissions was estimated as 4% for both limestone and dolomite.

● ***Time-series consistency***

Limestone and dolomite consumption data provided in the Adjusted Price Transaction Table is used as limestone and dolomite use activity data for all years from FY1990. The emission factors are constant for all years from FY1990. Therefore, CO_2 emission from limestone and dolomite use has been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

Recalculations have been conducted for the whole time-series, based on updates made to limestone consumption data in the Adjusted Price Transaction Table. Also recalculations have been conducted for 2005 to 2013, based on updates made to dolomite consumption data in the Adjusted Price Transaction Table. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.4.2. Ferroalloys Production (2.C.2.)

a) Category Description

1) CO_2

Ferroalloys are produced in Japan, and the CO_2 that is generated in association with the ferroalloys production is emitted as a result of the oxidization of coke used as a reducing agent. Consumption of coke is included in consumption of fuel under the Fuel Combustion Sector (1.A.), and CO_2 generated as a consequence of the oxidization of coke used as a reduction agent has already been calculated under the Fuel Combustion Sector (1.A.). Residual carbon in the ferroalloys is oxidized when the ferroalloys are used in the production of steel, and are released into the atmosphere as CO_2. Therefore, it has been reported as “IE”.

2) CH_4

Ferroalloys are manufactured in Japan in electric arc furnaces, small-scale blast furnaces, and Thermit furnaces. CH_4 generated in association with ferroalloy production is thought to be generated when the oxidization of coke, a reduction agent, takes place.

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from ferroalloy production were calculated by multiplying an emission factor based on actual measurements obtained in Japan by the energy consumption of electric arc furnaces. This is the same method used for calculating CH_4 emissions in the Fuel Combustion Sector (1.A.1. Energy Industries).

- ***Emission Factors***

The value for the emission factor of electric arc furnaces (12.8 kg-CH_4/TJ) was used because these furnaces produce ferroalloys.

- ***Activity Data***

Energy consumption amounts included in the "ferroalloy" category for the iron and steel industries of the *General Energy Statistics* were used.

Table 4-48 Energy consumption for ferroalloy production

Electricity consumption	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Electric furnaces (for Ferroalloys)	TJ	14,456	10,699	10,181	10,072	8,783	8,676	8,578	8,458	9,510	8,938	10,038	9,956	9,102

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty for the emission factor has been estimated as 163% and the uncertainty for activity data has been estimated as 5% (see chapter 3). As a result, the uncertainty for CH_4 emissions has been estimated as 163%.

- ***Time-series Consistency***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, CH_4 emissions from furnaces for ferroalloy have been estimated in a consistent manner throughout the time-series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.4.3. Aluminum Production (2.C.3.)

4.4.3.1. By-product emissions (2.C.3.-)

a) Category Description

1) CO_2

Aluminum refining is conducted in Japan. CO_2 generated in association with aluminum smelting is emitted in conjunction with the oxidization of the anode paste used as a reducing agent. Consumption of coke, the main ingredient in the anode paste has been included in fuel consumption under the Fuel combustion sector (1.A.), and the CO_2 that is generated by the oxidization of coke used as a reducing agent has already been calculated under the Fuel combustion sector (1.A.). Therefore, it has been reported as “IE”.

In addition to coke, binder pitch is also used in anodes paste for aluminum refining. All of this pitch is produced from by-product coal tar from coke ovens in Japan, where the coal tar consumption is treated as energy use under the Industry sector of the *General Energy Statistics*. None of it is imported. Therefore, emissions are accounted for under stationary combustion in the energy sector.

2) PFCs

PFCs are emitted during aluminum refining, due to the use of a fluoride melt consisting mainly of cryolite during electrolysis.

b) Methodological Issues

- ***Estimation Method***

Estimating emissions involved multiplying the production amount of primary aluminum refining by Japan's country-specific emission factors calculated using the equation prescribed in the *2006 IPCC Guidelines*.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by extrapolation etc of relevant data for these years.

- ***Emission Factors***

The equation prescribed in the Tier 2 method of the *2006 IPCC Guidelines*, and its associated slope coefficients set by technology, together with the weight fraction of gases was used to determine emission factors, as shown in the table below.

For the years 1990 to 1994, the emission factor for 1995 is used.

Table 4-49 PFC emission factors and aluminum production amounts

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PFC-14 (CF_4)	kg-PFC-14/t	0.709	0.709	0.482	0.398	0.392	0.388	0.388	0.390	0.388	0.387	0.386	0.386	0.386
PFC-116 (C_2F_6)	kg-PFC-116/t	0.060	0.060	0.041	0.034	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
Production of aluminium	t	34,100	17,338	6,500	6,490	6,600	6,610	6,600	4,930	4,670	4,670	4,075	2,950	588

Source: Yearbook of Minerals and Non-Ferrous Metals Statistics, Ministry of Economy, Trade and Industry, Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry

- ***Activity Data***

As the activity data for PFC emissions from aluminum refining, the aluminum production amounts given in the *Yearbook of Minerals and Non-Ferrous Metals Statistics* compiled by the Ministry of Economy, Trade and Industry (1995 to 1997), and Documents of the Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry (previously the Group for Prevention of Global Warming, Chemical and Bio Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry) (1998 and beyond), were used.

For the years 1990 to 1994, aluminum production amounts given in the *Yearbook of Minerals and Non-Ferrous Metals Statistics* compiled by the Ministry of Economy, Trade and Industry were used.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor and uncertainty of the activity data, the respective default values of 44% and 2% in the *2006 IPCC Guidelines* were applied. As a result, the uncertainty of the emissions was determined to be 44%.

- ***Time-series Consistency***

See section 4.3.9.1. c)

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d)

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.4.3.2. F-gases used in foundries (2.C.3.-)

Emission from this source was reported as “NO” as it was been confirmed that Japan had no record of the use of SF_6 in aluminum forging processes.

4.4.4. Magnesium Production (2.C.4.)

a) Category Description

HFCs and SF_6 are emitted in magnesium foundries, due to its use as cover gas to prevent oxidation of molten magnesium.

b) Methodological Issues

Emissions are an aggregation of all HFCs and SF_6 used by magnesium foundries. The data that has been reported is given in documentation prepared by the Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group of the Ministry of Economy, Trade and Industry’s Industrial Structure Council, for emissions of HFCs and SF_6 used in magnesium foundries. The associated indices are given in the table below.

Table 4-50 Indices related to HFCs and SF_6 emitted from magnesium foundries

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Consumption of HFC-134a	t	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.9	0.9	0.9
Consumption of SF_6	t	6.4	5.0	43.0	48.4	45.7	45.6	27.3	10.0	12.9	8.0	8.0	7.0	8.0

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using other die cast production amounts which is thought to be proportional to molten magnesium amounts, and the consumption amount of SF_6 from 1995, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of emissions was set at the 5% value of the upper limit for the Tier 2 method in the *2006 IPCC Guidelines.*

- ***Time-series Consistency***

See section 4.3.9.1. c)4.4.3.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.4.5. Lead production (2.C.5.)

CO_2 generated from lead production are emitted by the oxidization of coke used as reductants. The amount of coke consumed as reductant used in lead production is included under "Direct heating purposes" (a fuel category under non-ferrous bare metal industry) in the *Yearbook of the Current Survey of Energy Consumption*. Since emissions are already accounted for under 1.A.2. Manufacturing industries and construction in the Energy sector, emissions are reported as IE.

4.4.6. Zinc production (2.C.6.)

Similar to lead, CO_2 generated from zinc production are emitted by the oxidization of coke used as reductants. The amount of coke consumed as reductants used in zinc production is included under "Direct heating purposes" (a fuel category under non-ferrous bare metal industry) in the *Yearbook of the Current Survey of Energy Consumption*. Since emissions are already accounted for under 1.A.2. Manufacturing industries and construction in the Energy sector, emissions are reported as IE.

When Smithsonite ($ZnCO_3$) which includes carbon in the ore are used as raw material, there is the possibility of CO_2 arising from the ore in the reduction process. However, there are currently no cases of Smithsonite use in Japan.

4.5. Non-energy products from fuels and solvent use (2.D.)

This category covers CO_2 emissions from the use of non-energy products from fuels and solvents. This section includes GHG emissions from the following sources: Lubricant use (2.D.1.), Paraffin wax use (2.D.2.), and Urea used as a catalyst (2.D.3.).

In 2014, emissions from this category were 295 kt-CO_2 eq. and represented 0.02% of Japan's total GHG emissions (excluding LULUCF). The emissions had decreased by 24.8% compared to 1990.

Table 4-51 Emissions from 2.D. Non-energy Products from Fuels and Solvent Use

Gas	Emission sub-category				Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	2.D Non-energy Products from Fuels and Solvent Use	2.D.1	Lubricant use		kt-CO_2	343	353	350	324	332	318	298	302	303	284	259	269	266
		2.D.2	Paraffin wax use		kt-CO_2	50	37	36	36	36	38	31	30	35	30	27	27	26
		2.D.3	Other	Urea-based catalysts	kt-CO_2	NO	NO	NO	0.12	0.27	0.39	0.52	0.64	0.97	1.52	2.30	3.11	3.71
	Total				kt-CO_2	392	390	385	361	368	356	329	333	339	316	288	299	295

4.5.1. Lubricant use (2.D.1.)

a) Category Description

CO_2 is emitted from the oxidation of lubricants and grease during use. Emissions from the total loss type of engine oil are reported in the energy sector (See 1.A.3.), and emissions from other types than the above-mentioned type of engine oil are reported under this sector.

b) Methodological Issues

- ***Estimation Method***

Emissions were calculated by multiplying lubricant and grease consumption amounts per oil type, by the carbon content and oxidation during use (ODU) factor per oil type, based on the Tier 2 method given in the *2006 IPCC Guidelines*. (See below)

$$E = \sum_i \left(LC_i * CC_i * ODU_i * 44/12 \right)$$

E : Emissions from the oxidation of lubricants and grease during use (kt-CO_2)
LCi : Lubricant and grease consumption amounts (TJ)
CCi : Carbon content of fuel (kt-C/TJ)
ODUi : ODU factor for oil
i : Type of lubricant and grease

- ***Emission Factors***

For carbon content, the carbon emission factors of lubricants and heavy oil products in the *General Energy Statistics* (Agency for Natural Resources and Energy) are used. For the ODU factor, the default values in the *2006 IPCC Guidelines* are used. (lubricants: 0.2, grease: 0.05)

- ***Activity Data***

For lubricants, the consumption amounts for types other than total loss types of engine oil are calculated by subtracting the consumption amounts of the total loss type from the total of consumption amounts of engine oil. (See 3.2.8. Activity data)

For grease, the consumption amounts are calculated by multiplying the domestic sales amounts in the *Yearbook of Mineral Resources and Petroleum Products Statistics* and the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke*, by the calorific values of heavy oil products in the *General Energy Statistics*. However, for years 1992 to 1999, the domestic sales data are not available from these statistics. Therefore, the domestic sales for these years are estimated by subtracting the total of exports and stocks at the end of the year, from the total of stocks at the start of the year and production and imports, which are respectively shown in these statistics.

Table 4-52 Consumption of engine oil (for types other than total loss types) and grease

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Consumption of engine oil (for types other than total loss types)	TJ	23,449	24,385	24,144	22,298	22,783	21,717	20,449	20,804	20,768	19,476	17,756	17,788	17,572
Consumption of grease	TJ	3,152	2,503	2,435	2,658	2,822	3,081	2,530	2,299	2,622	2,573	2,339	2,462	2,497

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of emission factors, a 50% default value in the *2006 IPCC Guidelines* was applied for both lubricants and grease. For the uncertainty of the activity data, a 5% default value in the *2006 IPCC Guidelines* was applied for both lubricants and grease. As a result, the uncertainty of emissions was assessed to be 50% for both lubricants and grease.

- ***Time-series Consistency***

For activity data, the same source-the *Yearbook of Chemical Industries Statistics*, and the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* etc are used throughout the time series. The emission factors are constant throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

The gross calorific value for grease was revised for 2012, and the amount of sales of lubricants (partially oxidized) was revised for 2013. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.5.2. Paraffin wax use (2.D.2.)

a) Category Description

CO_2 is emitted from the oxidation of paraffin wax during use.

b) Methodological Issues

- ***Estimation Method***

Emissions were calculated based on the Tier 1 method given in the *2006 IPCC Guidelines*. (See below)

$$E_{CO_2} = PW * CC_{Wax} * ODU_{Wax} * 44/12$$

PW : Paraffin wax consumption amounts (TJ)
CC_{Wax} : Carbon content of paraffin wax (kg-C/GJ)
ODU_{Wax} : ODU factor for paraffin wax

- ***Emission Factors***

For carbon content, the carbon emission factor of heavy oil products in the *General Energy Statistics* (Agency for Natural Resources and Energy) is used. For the ODU factor, the default value in the *2006 IPCC Guidelines* is used. (0.2)

- ***Activity Data***

The consumption amounts are calculated by multiplying the domestic sales amounts in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and *Yearbook of Mineral Resources and Petroleum Products Statistics*, by the calorific values of heavy oil products in the *General Energy Statistics*.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of emission factors, a 100% default value in the *2006 IPCC Guidelines* was applied. For the uncertainty of the activity data, a 5% default value in the *2006 IPCC Guidelines* was

applied. As a result, the uncertainty of emissions was assessed to be 100%.

- ***Time-series Consistency***

For activity data, the same source-the *Yearbook of Chemical Industries Statistics*, and the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* etc are used throughout the time series. The emission factors are constant throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

The gross calorific value for paraffin wax was revised for 2012. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.5.3. Other (2.D.3.)

4.5.3.1. Urea used as a catalyst (2.D.3.-.)

a) Category Description

The urea SCR system for cars is a technology to reduce NOx emissions, by the reduction of NOx in exhaust gas using ammonia, and decomposing it into N_2 and H_2O. By spraying urea aqueous into high temperature exhaust gas, this is hydrolyzed to yield ammonia gas, and CO_2 is emitted as follows.

$$CO(NH_2)_2 + H_2O \rightarrow 2NH_3 + CO_2$$

b) Methodological Issues

- ***Estimation Method***

Emissions were calculated based on the *2006 IPCC Guidelines*. (See below)

$$E_{CO_2} = AD * 12/60 * P * 44/12$$

AD: Consumption amount of urea-based additives in urea SCR systems [kt]
P: Ratio of urea in urea-based additives [%] (Default value: 32.5%)

- ***Emission Factors***

For the Ratio of urea in urea-based additives (P), the default value of 32.5% in the *2006 IPCC Guidelines* is used.

- ***Activity Data***

The Number of cars with urea SCR systems (data provided by the Japan Automobile Manufacturers Association) is first multiplied by the consumption amount of diesel oil per car, and then further multiplied by ratio of consumption amount of urea-based additives to diesel, to yield the consumption amount of urea-based additives. This is then multiplied by the ratio of imports to the domestic total

consumption to finally yield the consumption amount of urea-based additives for imports only[7].

$$AD = N * L * R * D * I$$

AD: Consumption amount of urea -based additives in urea SCR systems [kt]
N: Number of cars with urea SCR systems [thousand cars]
L: Consumption amount of diesel oil per car [kL/car]
R: Ratio of consumption amount of urea-based additives to diesel [%]
D: Density of diesel oil [t/kL]
I: Ratio of imports [%]

Table 4-53 Parameters used to calculate the consumption amount of urea -based additives, and their sources and methods of establishment

Item	Sources and methods of establishment
Number of cars with urea SCR systems [thousand cars]	Data provided by the Japan Automobile Manufacturers Association
Consumption amount of diesel oil per car [kL/car]	Calculated by dividing the total consumption amount of diesel based on the *Statistical Yearbook of Motor Vehicle Transport* and *Statistical Yearbook of Motor Vehicle Fuel Consumption* (Ministry of Land, Infrastructure, Transport and Tourism) by the total number of registered cars
Ratio of consumption amount of urea-based additives to diesel [%]	2%, as a median value of 1 to 3 % in the *2006 IPCC Guidelines*
Density of diesel oil [t/kL]	0.8831t/kL, based on the *Handbook on the General Energy Statistics* (RIETI)
Ratio of imports [%]	Ratio of urea imports to (domestic shipment amounts + imports) for each year, based on the *Yearbook of Fertilizer Statistics (Pocket Edition)* (Ministry of Agriculture, Forestry and Fisheries)

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of emission factor, a 5% default value in the *2006 IPCC Guidelines* (cars - combustion origin) was applied. For the uncertainty of the activity data, a 5% default value in the *2006 IPCC Guidelines* was applied. As a result, the uncertainty of emissions was assessed to be 7%.

- ***Time-series Consistency***

For activity data, the same source-data provided by the Japan Automobile Manufacturers Association etc are used throughout the time series. The emission factors are constant throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

The change in the statistics used to calculate the consumption amount of diesel oil per car resulted in recalculations for the whole time-series. See Chapter 10 for impact on trend.

[7] Domestically produced urea is from CO_2 recovered from ammonia production processes, and therefore the CO_2 associated with it is already included in 2.B.1. Ammonia production emissions.

f) Category-specific Planned Improvements

No improvements are planned.

4.5.3.2. Road Paving with Asphalt (2.D.3.-)

Roads in Japan are paved with asphalt, but almost no CO_2 are thought to be emitted in the process. It is not possible, however, to be completely definitive about the absence of emissions. Emissions have also never been actually measured, and as no default emission value is available, it is not currently possible to calculate emissions. Therefore, it has been reported as "NE".

4.5.3.3. Asphalt Roofing (2.D.3.-)

Asphalt roofing is manufactured in Japan, but information on the manufacturing process and activity data is inadequate, and it is not possible to definitively conclude that CO_2 is not emitted from the manufacturing of asphalt roofing. Emissions have also never been actually measured, and as no default emission value is available, it is not currently possible to calculate emissions. Therefore, it has been reported as "NE".

4.6. Electronics industry (2.E.)

This category covers HFC, PFC, SF_6, and NF_3 emissions from the manufacturing of the electronic devices. This section includes GHG emissions from the following sources: Semiconductor (2.E.1.), Liquid Crystals (2.E.2.), Photovoltaics (2.E.3.), and Heat transfer fluid (2.E.4.).

In 2014, emissions from Electronics industry were 2,346 kt-CO_2 eq., and represented 0.2% of Japan's total GHG emissions (excluding LULUCF). The emissions had increased by 23.2% compared to 1990.

Table 4-54 Emissions from 2.E. Electronics Industry

Gas	Emission sub-category			Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFCs	2.E Electronics Industry	2.E.1	Semiconductor	kt-CO_2 eq.	0.73	270.62	282.71	223.98	242.72	262.78	234.21	149.81	164.93	142.19	121.63	109.24	112.89
		2.E.2	Liquid crystals□	kt-CO_2 eq.	0.001	0.266	1.838	2.978	2.829	3.062	2.834	2.298	3.021	3.277	2.389	2.368	2.260
	Total			kt-CO_2 eq.	0.732	270.882	284.553	226.954	245.553	265.840	237.041	152.108	167.948	145.468	124.016	111.609	115.154
PFCs	2.E Electronics Industry	2.E.1	Semiconductor	kt-CO_2 eq.	1,423.43	3,933.17	6,771.47	4,594.11	4,934.79	4,432.88	3,338.90	2,109.08	2,214.33	1,863.33	1,624.17	1,555.73	1,616.86
		2.E.2	Liquid crystals□	kt-CO_2 eq.	31.35	86.62	214.10	152.03	157.60	106.94	83.50	39.32	46.50	59.12	68.22	75.63	89.74
	Total			kt-CO_2 eq.	1,454.78	4,019.79	6,985.57	4,746.14	5,092.38	4,539.83	3,422.39	2,148.40	2,260.83	1,922.45	1,692.39	1,631.36	1,706.59
SF_6	2.E Electronics Industry	2.E.1	Semiconductor	t	13.56	17.54	27.58	23.69	20.32	18.89	14.41	9.25	9.86	8.62	8.05	7.96	7.66
		2.E.2	Liquid crystals□	t	4.81	6.22	38.48	31.22	25.11	16.03	12.98	8.75	11.79	8.68	7.55	7.45	8.38
	Total			t	18.36	23.77	66.05	54.91	45.43	34.92	27.39	18.00	21.65	17.30	15.60	15.41	16.04
	Total			kt-CO_2 eq.	418.70	541.85	1505.96	1251.97	1035.79	796.11	624.54	410.31	493.66	394.42	355.59	351.31	365.83
NF_3	2.E Electronics Industry	2.E.1	Semiconductor	t	1.59	9.78	5.79	9.36	11.23	14.25	13.21	10.59	11.09	10.16	10.29	6.38	7.67
		2.E.2	Liquid crystals□	t	0.15	0.91	3.83	4.10	4.94	6.60	1.79	1.34	1.53	1.41	1.21	1.24	1.52
	Total			t	1.73	10.69	9.61	13.47	16.17	20.86	15.01	11.93	12.62	11.57	11.50	7.63	9.20
	Total			kt-CO_2 eq.	29.82	183.89	165.37	231.63	278.15	358.72	258.12	205.20	217.06	199.06	197.77	131.16	158.20
Total of All Gases				kt-CO_2 eq.	1,904.04	5,016.42	8,941.45	6,456.69	6,651.88	5,960.50	4,542.10	2,916.02	3,139.50	2,661.40	2,369.77	2,225.44	2,345.77

4.6.1. Semiconductor (2.E.1.)

a) Category Description

HFCs, PFCs, SF_6, and NF_3 are emitted from the manufacturing of semiconductors.

b) Methodological Issues

- ***Estimation Method***

The Tier 2a method of the *2006 IPCC Guidelines* is used to estimate emissions from semiconductors. These emissions are estimated with purchase of F-gases, process supply rate, use rate of F-gas, removal rate, by-product generation ratio and removal ratio for by-products. The process supply rate is country-specific.

Regarding the treatment of the 10% residue after process supply, these emissions are reported under this category when there is a 90% recharging and subsequent shipment. In cases of decomposing the residual 10% and cleansing the containment shell, or release into the atmosphere, these emissions are reported under "2.B.9. Fluorochemical production – fugitive emissions".

Japan Electronics and Information Technology Industries Association data are used for F-gases purchased.

F-gas emissions in Semiconductor Manufacturing
Methods below are applied for each gas:

(i) HFC-23, PFCs (PFC-14, PFC-116, PFC-218, PFC-c318), SF_6, and NF_3 emissions

Emissions
= purchased amount of gas × process supply rate × (1 – use rate of gas)
× (1 – fraction of gas controlled × fraction of gas destroyed)

(ii) By-produced PFC-14 etc emissions

Emissions
= purchased amount of gas × by-production rate × process supply rate
× (1 – fraction of gas controlled × fraction of gas destroyed)

Relevant indices are shown in Table below.

Table 4-55 Indices related to emissions of F-gases from manufacturing of semiconductors

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-23 purchased	t	0.1	47.8	49.4	42.1	48.6	62.1	73.7	53.8	67.1	68.4	66.7	66.7	77.2
PFC-14 purchased	t	113.3	313.0	299.9	231.5	232.9	277.5	276.9	208.9	265.3	248.3	222.4	218.1	253.6
PFC-116 purchased	t	75.8	209.5	561.2	393.2	355.6	321.0	284.9	171.5	194.3	159.9	139.4	117.8	105.5
PFC-218 purchased	t	0.01	0.03	9.91	181.80	189.18	195.14	180.98	129.47	166.96	137.00	115.48	106.08	117.19
PFC-c318 purchased	t	0.2	0.6	38.6	24.8	28.3	33.4	40.2	33.3	35.8	36.8	39.7	42.2	52.6
SF_6 purchased	t	70.1	90.8	131.9	96.8	85.8	82.9	79.1	60.2	76.7	65.2	63.7	57.6	64.9
NF_3 purchased	t	8.8	54.4	106.3	406.7	600.1	730.7	821.8	724.8	860.7	834.5	880.5	905.4	1055.3
Process supply rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Use rate of PFC etc	%	10 - 98 %												
Fraction of PFCs, and SF_6 destroyed	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Fraction of NF_3 destroyed	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
CF_4 by-production rate	%	2 - 20 %												
By-product CF_4 removal rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
HFC emissions	Mt-CO_2 eq.	0.001	0.271	0.283	0.224	0.243	0.263	0.234	0.150	0.165	0.142	0.122	0.109	0.113
PFC emissions	Mt-CO_2 eq.	1.423	3.933	6.771	4.594	4.935	4.433	3.339	2.109	2.214	1.863	1.624	1.556	1.617
SF_6 emissions	Mt-CO_2 eq.	0.309	0.400	0.629	0.540	0.463	0.431	0.329	0.211	0.225	0.196	0.184	0.181	0.175
NF_3 emissions	Mt-CO_2 eq.	0.027	0.168	0.100	0.161	0.193	0.245	0.227	0.182	0.191	0.175	0.177	0.110	0.132

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry, and data provided by the Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using available domestic HFC, PFC, and SF_6 shipment amount, and NF_3 production amount data which is thought to be proportional to HFC, PFC, SF_6, and NF_3 emissions, and

extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, *2006 IPCC Guidelines* default values of 100%, 80%, 300%, and 70% were respectively applied for HFCs, PFCs, SF_6, and NF_3. For the uncertainties of the activity data, 10% was applied for all HFCs, PFCs, SF_6, and NF_3, using the upper limit value in the *2006 IPCC Guidelines*. As a result, the uncertainties of the emissions for HFCs, PFCs, SF_6, and NF_3, were determined to be 100%, 81%, 300%, and 71%, respectively.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.6.2. Liquid Crystals (2.E.2.)

a) Category Description

HFCs, PFCs, SF_6, and NF_3 are emitted from the manufacturing of liquid crystals.

b) Methodological Issues

- ***Estimation Method***

Same methods applied to semiconductors are also applied to emissions from manufacturing of liquid crystals. The process supply rate is country-specific. World LCD Industry Cooperation Committee has established a voluntary action plan to reduce PFC emissions and has engaged in reducing PFC emissions. In these activities, IPCC methods should be applied.

Table 4-56 Indices related to emissions of F-gases from manufacturing of liquid crystals

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-23 purchased	t	0.0003	0.1	0.7	1.6	1.6	1.7	1.5	1.1	1.1	1.2	1.0	1.3	1.5
PFC-14 purchased	t	7.5	20.7	47.3	77.8	86.5	80.4	69.3	51.9	93.7	124.3	121.1	154.5	191.7
PFC-116 purchased	t	0.1	0.4	2.7	9.9	8.7	5.2	4.1	2.3	0.0	0.0	0.0	0.0	0.0
PFC-c318 purchased	t	0.0	0.0	0.0	0.8	1.2	2.0	1.9	1.7	1.6	1.9	1.7	1.4	1.8
SF_6 purchased	t	8.9	11.5	85.3	101.4	106.5	117.4	146.8	127.1	176.9	129.0	104.1	107.4	126.2
NF_3 purchased	t	1.3	8.1	106.9	232.2	296.0	438.9	556.1	532.2	764.1	718.0	668.0	783.8	918.9
Process supply rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Use rate of PFCs etc	%	40 - 97 %												
Fraction of PFCs, and SF_6 destroyed	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Fraction of NF_3 destroyed	%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
CF_4 by-production rate	%	0.9 - 7 %												
By-product CF_4 removal rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
HFC emissions	Mt-CO_2 eq.	0.000001	0.0003	0.002	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.002	0.002	0.002
PFC emissions	Mt-CO_2 eq.	0.031	0.087	0.214	0.152	0.158	0.107	0.083	0.039	0.046	0.059	0.068	0.076	0.090
SF_6 emissions	Mt-CO_2 eq.	0.110	0.142	0.877	0.712	0.572	0.366	0.296	0.199	0.269	0.198	0.172	0.170	0.191
NF_3 emissions	Mt-CO_2 eq.	0.003	0.016	0.066	0.071	0.085	0.114	0.031	0.023	0.026	0.024	0.021	0.021	0.026

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using available domestic HFC, PFC, SF_6 shipment, and NF_3 production amount data which is thought to be proportional to HFC, PFC, SF_6, and NF_3 emissions, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.6.1. c).

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.6.3. Photovoltaics (2.E.3.)

Photovoltaics manufacturing using PFCs is only done by one company inside Japan, and therefore emissions are reported as “C”, and included in PFC emissions from semiconductor manufacturing.

4.6.4. Heat transfer fluid (2.E.4.)

In the process of electronics manufacturing, fluorinated compounds are used for temperature control. These fluorinated compounds are released through evaporative losses during the cooling of process equipment etc. Emissions were reported as “IE” since PFCs in this category are included in the total reported in 4.7.5. Solvents (2.F.5.), where liquid PFCs etc are collectively captured.

4.7. Product uses as substitutes for ODS (2.F.)

This category covers HFC and PFC emissions from the use of the products that are substitutes for ozone depleting substances (ODS). This section includes GHG emissions from the following sources: Refrigeration and air conditioning (2.F.1.), Foam blowing agents (2.F.2.), Fire protection (2.F.3.), Aerosols (2.F.4.), and Solvents (2.F.5.).

In 2014, emissions from this category were 37,081 kt-CO_2 eq., and represented 2.7% of Japan's total GHG emissions (excluding LULUCF). The emissions had increased by a factor of 7.15 since 1990.

Table 4-57 Emissions from 2.F. Product uses as substitutes for ODS

Gas	Emission sub-category			Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFCs	2.F Product Uses as Substitutes for ODS	2.F.1	Refrigeration and air conditioning	kt-CO_2 eq.	NO	925	2,977	8,876	10,854	13,468	15,685	17,998	20,482	23,139	26,353	29,002	32,556
		2.F.2	Foam blowing agents	kt-CO_2 eq.	1	497	484	937	1,194	1,429	1,510	1,608	1,749	1,923	2,081	2,229	2,373
		2.F.3	Fire protection	kt-CO_2 eq.	NO	NO	5	7	7	8	8	8	8	8	9	9	9
		2.F.4	Aerosols	kt-CO_2 eq.	NO	1,502	3,117	1,695	1,123	895	931	845	666	634	561	489	503
		2.F.5	Solvents	kt-CO_2 eq.	NO	NO	NO	4	5	10	14	42	50	52	81	98	103
	Total			kt-CO_2 eq.	1	2,923	6,583	11,519	13,184	15,809	18,148	20,501	22,956	25,757	29,085	31,827	35,544
PFCs	2.F Product Uses as Substitutes for ODS	2.F.5	Solvents	kt-CO_2 eq.	4,550	12,572	3,200	2,815	2,793	2,377	1,648	1,420	1,721	1,605	1,583	1,518	1,537
Total of All Gases				kt-CO_2 eq.	4,551	15,495	9,783	14,334	15,976	18,186	19,796	21,921	24,676	27,362	30,668	33,345	37,081

4.7.1. Refrigeration and Air Conditioning Equipment (2.F.1.)

4.7.1.1. Domestic Refrigeration Production, Use and Disposal (2.F.1.-)

a) Category Description

1) HFCs

HFCs are emitted from the production, use (including failure of devices), and disposal of domestic refrigeration.

2) PFCs

Emission from this source in the "production" category was reported as "NO" as Japan had no record of their use in the production of the products. The emission was also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products, or refrigerants were refilled.

b) Methodological Issues

- ***Estimation Method***

The collected amount of HFCs under regulation was subtracted from 1) fugitive refrigerant ratio from production, 2) fugitive refrigerant ratio from use (including failure of devices), and 3) refrigerant contained at the time of disposal, separately, based on production and shipment amounts and refrigerant contained. Then, all there were combined.

Emissions from use and disposal were estimated by summing up the values calculated for each year of the production of devices. Emission factors are country-specific.

Emissions of HFCs from Domestic Refrigeration

HFC emissions = total refrigerant contained at production × fugitive refrigerant ratio at production
+ ∑ (number of operated devices containing HFCs × refrigerant contained per operated device × fugitive refrigerant ratio from use)
+ ∑ (number of disposed devices containing HFCs × refrigerant contained per disposed device)
- collected amount of HFCs

The associated indices are given in the table below.

Table 4-58 Indices related to emissions of HFCs from domestic refrigeration

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total HFCs charged in the year of production	t	NO	520	590	0.3	0.4	0.3	NO	NO	NO	NO	NO	NO	NO
Fugitive refrigerant ratio at production	%	1%	1%	1%	0%	0%	NO	NO	NO	NO	NO	NO	NO	NO
Number of operated HFC devices	1,000 devices	NO	7829	33213	41796	39754	37225	34509	31471	28085	24509	20984	17637	14520
Refrigerant charged per device at production	g	150	150	125	125	125	125	125	125	125	125	125	125	125
Operational fugitive ratio (including failure)	%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Number of HFC devices disposed	1,000 devices	NO	NO	177	1839	2314	2771	3154	3445	3588	3600	3456	3204	2850
Amount of HFCs collected under law	t/year	–	–	–	52	68	91	111	111	111	160	169	189	166
Emissions	t	NO	8.72	40.08	187.84	227.73	259.46	283.93	317.02	332.33	282.70	254.22	202.01	180.75
	Mt-CO_2 eq.	NO	0.012	0.057	0.269	0.326	0.371	0.406	0.453	0.475	0.404	0.364	0.289	0.258

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic refrigeration shipment amounts, the ratio of devices with HFCs, and HFCs charged per shipment amount (derived from shipment amounts from 1995, the ratio of devices with HFCs from 1995, and total HFCs charged during production from 1995), fugitive refrigerant ratio at production from 1995, refrigerant charged per device at production from 1995, operational fugitive ratio from 1995, number of HFC devices disposed from 1995, and extrapolating etc for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, the 30% upper limit value for electrical equipment in the *2006 IPCC Guidelines* was applied for all production and use. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all production, use, and disposal. As a result, the uncertainties of the emissions for production and use were determined to be 32%, and 10% for disposal.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.1.2. Commercial Refrigeration Production, Use and Disposal (2.F.1.-)

4.7.1.2.a. Commercial Refrigeration

a) Category Description

1) HFCs

HFCs are emitted from the manufacturing, operation, maintenance, accidents, and disposal of commercial refrigeration.

2) PFCs

Emissions from this source in the "production" category were reported as "NO" as Japan had no record of their use in the production of the products. The emissions were also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products, or refrigerants were refilled.

b) Methodological Issues

- ***Estimation Method***

Estimation is mainly conducted using a model, by taking into account the type of device and year of production etc, and based on the principles of the *2006 IPCC Guidelines*. Using the number of devices produced per type and amount of refrigerant per type contained etc for each year, emissions of each species of F-gases from 1) manufacturing, 2) installation, 3) operation and 4) disposal are estimated for the devices below, and then aggregated.

centrifugal refrigerating machine, screw refrigerating machine, refrigerator-freezer unit, transport refrigerator-freezer unit, separately placed showcase, built-in showcase, ice making machinery, water fountain, commercial refrigerator-freezer, all-in-one air conditioning system, gas heat pump, chilling unit

Emission factors were determined by a large sample survey conducted on the amount of refrigerant charge and the occurrence of failure in a certain time-period, by each type of equipment[8]. (260,000 sample units, conducted from 2007 to 2009. Emission factors are country-specific.

[8] For details, refer to document 1-1 and 1-2 of the 21st meeting of the Group for Prevention of Global Warming, Chemical and Bio Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, held on March 17, 2009.

Emissions of HFCs from Commercial Refrigeration

Methods below are applied to each type of device and refrigerant

1) manufacturing
Emissions from manufacturing = Σ (number of device produced × amount of refrigerant contained × fugitive refrigerant ratio from manufacturing)
2) installation
Emissions from operation = Σ (number of device charged refrigerant in place produced × amount of refrigerant contained × fugitive refrigerant ratio from installation)
3) operation
Emissions from maintenance = Σ (number of devices operated × amount of refrigerant contained × fugitive refrigerant ratio from operation) - amount collected
4) disposal
Emissions from disposal = Σ (number of devices disposed × average amount of refrigerant contained) - amount collected

* In the estimation of emissions from maintenance, the yearly decrease is reflected in the "amount of refrigerant contained." The "number of devices operated" and "number of devices disposed" are estimated from the amount of shipment and lifetime of device.

The associated indices are given in the table below.

Table 4-59 Indices related to emissions of HFCs from commercial refrigeration

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced	1,000 devices	NO	214	374	1,413	1,339	1,391	1,444	987	1,122	1,198	1,212	1,303	1,250
Average amount of refrigerant charged at production	g/device	372	372	597	3,378	3,627	3,548	3,533	3,276	3,280	3,360	3,462	3,413	3,539
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%	0.2%	0.2%	0.2%	0.1%
Number of devices charged in production place	1,000 devices	NO	9	32	138	168	190	199	175	171	190	239	225	260
Average amount of refrigerant during installation	g/device	17,806	17,806	9,221	23,914	26,073	25,170	26,676	25,955	24,527	24,276	22,826	20,754	20,394
Fugitive refrigerant ratio during installation	%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Number of devices operated	1,000 devices	NO	375	1,957	6,770	7,884	8,983	10,027	10,847	11,743	12,678	13,616	14,568	15,414
Amount of refrigerant during operation	g/device	1,012	1,012	1,043	4,549	5,024	5,361	5,632	5,802	5,981	6,192	6,440	6,596	6,799
Fugitive refrigerant ratio during use	%	2 - 17%												
Number of devices disposed	1,000 devices	NO	1	23	127	169	220	269	325	397	453	512	576	663
Amount of HFCs collected under law during maintenance	t	NO	NO	NO	NO	NO	236	436	503	548	571	671	682	759
Amount of HFCs collected under law after use	t	NO	NO	NO	183	206	186	200	230	269	352	522	689	668
Emissions from manufacturing	Mt-CO_2 eq.	NO	0.003	0.009	0.150	0.189	0.225	0.234	0.202	0.198	0.220	0.269	0.225	0.256
Emissions from stocks	Mt-CO_2 eq.	NO	0.040	0.258	3.415	4.921	6.346	7.646	9.035	10.524	12.233	14.231	15.850	17.638
Emissions from disposal	Mt-CO_2 eq.	NO	0.004	0.051	0.586	1.000	1.592	1.931	2.372	2.777	3.141	3.466	3.741	4.739
Emissions	Mt-CO_2 eq.	NO	0.047	0.318	4.151	6.111	8.164	9.810	11.609	13.499	15.594	17.965	19.815	22.633

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, and data provided by the Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* From 2002 onward, "amount of refrigerant" and "fugitive refrigerant ratio from operation" increased because devices became larger with the increase of commercial package AC devices.

Table 4-60 Indices related to emissions of HFCs from commercial refrigeration (railways)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced *	devices	14	53	30	0	1	20	20	0	0	0	0	0	0
Refrigerant charged per device at production *	kg	3	3	3	3	3	3	3	3	3	3	3	3	3
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Number of devices operated	devices	363	390	378	383	387	386	382	377	367	365	365	365	365
Refrigerant charged per device during use *	kg	3	3	3	3	3	3	3	3	3	3	3	3	3
Fugitive refrigerant ratio during use	%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Number of devices disposed	devices	1	7	5	1	1	9	10	10	14	9	13	8	8
Refrigerant stock in device disposed	kg	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Collection rate	%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Emissions from manufacturing	kt-CO_2 eq.	NO	NO	0.001	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions from stocks	kt-CO_2 eq.	NO	NO	0.080	0.395	0.434	0.484	0.674	0.665	0.648	0.644	0.644	0.644	0.644
Emissions from disposal	kt-CO_2 eq.	NO	NO	NO	NO	NO	NO	NO	0.018	0.025	0.016	0.023	0.014	0.014
Emissions	kt-CO_2 eq.	NO	NO	0.081	0.395	0.434	0.484	0.674	0.683	0.672	0.660	0.667	0.658	0.658

Source: Railway Statistical Yearbook, IPCC default values. * are from manufacturers.

Table 4-61 Indices related to emissions of HFCs from commercial refrigeration (vessels)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced *	devices	0	0	0-960	0-8,460	0-10,430	0-14,370	0-16,900	0-17,560	0-16,210	0-27,420	0-38,860	0-45,980	0-32,280
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Number of vessels operated	vessels	11,681	11,267	9,422	8,562	8,473	8,350	8,180	7,948	7,863	7,779	7,800	7,783	7,829
Refrigerant charged per vessel during use *	kg	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000	10-6,000
Fugitive refrigerant ratio during use	%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Number of devices disposed	devices	700	232	188	0	2	0	2	4	2	0	0	68	68
Refrigerant stock in device disposed by gas	kg	0	0	0	0	0	0	0	0	0-0.1	0-0.4	0-0.4	0-1.6	0-3.8
Collection rate	%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Emissions from manufacturing	kt-CO_2 eq.	NO	NO	0.008	0.066	0.082	0.113	0.133	0.138	0.127	0.215	0.305	0.361	0.256
Emissions from stocks	kt-CO_2 eq.	NO	NO	1.163	23.783	32.203	42.086	52.353	62.463	77.897	95.516	124.812	162.755	176.794
Emissions from disposal	kt-CO_2 eq.	NO	NO	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.067	0.155
Emissions	kt-CO_2 eq.	NO	NO	1.171	23.850	32.285	42.198	52.485	62.601	78.024	95.731	125.118	163.183	177.205

Source: IPCC default values, Report on Maritime Affairs etc. * are from manufacturers.

Table 4-62 Type of HFC and emission factors during use, by type of commercial refrigeration

Type of commercial refrigeration	Type of HFC	Amount of refrigerant	Emission factor *	Share in the number of devices operated (2010)
Small-size refrigerators (built-ins etc)	R-404A, HFC-134a etc	0.1 - 3 kg	2%	40%
Separately installed showcases	R-404A, R-407C etc	20 - 41 kg	16%	3%
Mid-size refrigerators (excluding Separately installed showcases)	R-404A, R-407C etc	2 - 30 kg	13 - 17%	6%
Large-size refrigerators	HFC-134a, R404A etc	300 - 2,300 kg	7 - 12%	0.05%
All-in-one air conditioning systems for buildings	R-410A, R-407C etc	37 kg	3.5%	7%
Other commercial air conditioning devices (excluding All-in-one air conditioning systems for buildings)	R-410A, R-407C etc	3 - 43 kg	3 - 5%	44%

Source: Documents of the 2nd Refrigerant Policy Working Group, Group for Prevention of Global Warming, Chemical and Bio Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry (July 26, 2010), and data provided by the Ministry of Economy Trade and Industry

* Includes for emissions during servicing, accidents, and breakdowns

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using HFC shipment amounts which is thought to be proportional to the number of HFC devices produced and number of devices charged in production place, and the average amount of refrigerant charged at production from 1995, fugitive refrigerant ratio at production from 1995, average amount of refrigerant during installation from 1995, fugitive refrigerant ration during installation from 1995, amount of refrigerant during operation from 1995, fugitive refrigerant ratio during use from 1995, and extrapolating etc for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, the 30% upper limit value for electrical equipment in the *2006 IPCC Guidelines* was applied for manufacturing. For use, a 5% value based on a METI survey was applied. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all manufacturing, use, and disposal. As a result, the uncertainties of the emissions for manufacturing, use, and disposal were determined to be 32%, 11%, and 10%, respectively.

- ***Time-series Consistency***

See section 4.3.9.1. c). From 1995 onward, production amount is taken from the same industry

organization of device manufacturers, and the EFs are values reported by the Ministry of Trade and Industry in 2009.

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

HFC emissions from railway and vessel refrigeration were newly estimated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.1.2.b. Automatic Vending machine Production, Use and Disposal

a) Category Description

1) HFCs

HFCs are emitted from manufacturing, accidents, and disposals of automatic vending machines.

2) PFCs

Emission from this source in the "production" category was reported as "NO" as Japan had no record of their use in production. The emissions were also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products or refrigerants were refilled.

b) Methodological Issues

- ***Estimation Method***

Emissions of F-gases from 1) manufacturing, 2) accidents and 3) disposals are estimated, based on production and shipment amounts and amounts of refrigerants charged. Emission factors are country-specific.

Emissions of HFCs from Automatic Vending machines

1) manufacturing
Emissions from manufacturing = Σ (number of device produced × amount of refrigerant contained × fugitive refrigerant ratio from manufacturing)
2) accident
Emissions from accident = Σ (number of devices operated × amount of refrigerant contained× incidence rate × average fugitive rate in accident)
3) disposal
(a) until 2001
Emissions from disposal = Σ {number of devices disposed × amount of refrigerant contained × (1 - collection rate) }
(b) from 2002 onward
Emissions from disposal = Σ (number of devices disposed × average amount of refrigerant contained) - amount collected

For HFC emissions from automatic vending machines, the values shown in the Documents of the

Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry is reported. The associated indices are given in the table below.

Table 4-63 Indices related to emissions of HFCs from automatic vending machines

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced	1,000 devices	NO	NO	272	355	338	301	270	173	173	124	30	10	8
Refrigerant charged per device	g	NO	NO	300	220	219	219	219	219	219	219	219	219	219
Fugitive refrigerant ratio at production	%	NO	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Number of devices operated	1,000 devices	NO	NO	284	1,999	2,265	2,393	2,384	2,368	2,279	2,055	1,759	1,497	1,184
Incidence rate	%	NO	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Fugitive refrigerant ratio (failure)	%	NO	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fugitive refrigerant ratio (fixing)	%	NO	0.009	0.009	0.005	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Number of devices disposed	1,000 devices	NO	NO	NO	NO	NO	183	213	293	286	347	277	273	299
Emissions	t	NO	NO	0	1	1	1	12	17	16	19	15	15	17
	Mt-CO_2 eq.	NO	NO	0.001	0.001	0.001	0.001	0.022	0.030	0.029	0.034	0.022	0.022	0.024

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* Accidents of devices charged with HFCs almost never occurred in 1999 and 2000, and therefore, were reported as 0. After 2001 onward, the number of accidents are reflected in the estimation.

For the years 1990 to 1994, it was confirmed that no automatic vending machines with HFCs were used, and therefore emissions for these years are reported as NO. (Ministry of the Environment press release, July 31, 2000, Projections of disposal etc of refrigerant CFCs, HCFCs, and HFCs (Reference material 1))

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, the 30% upper limit value for electrical equipment in the *2006 IPCC Guidelines* was applied for all manufacturing, use, and disposal. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all manufacturing, use, and disposal. As a result, the uncertainties of the emissions for all manufacturing, use, and disposal were determined to be 32%.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.1.3. Transport Refrigeration Production, Use and Disposal (2.F.1.-)

1) HFCs

Emission was reported as "IE" since HFCs in this category had been included in the total reported in 4.7.1.2.a Commercial Refrigeration (2.F.1.-).

2) PFCs

Emission from this source in the "production" category was reported as "NO" since Japan had no record of their use in the production. The emission was also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products or refrigerants were refilled.

4.7.1.4. Industrial Refrigeration Production, Use and Disposal (2.F.1.-)

1) HFCs

HFCs emissions have been reported as "IE", as they are included in 4.7.1.2. Commercial Refrigeration (2.F.1.-).

2) PFCs

Emission from this source in the "production" category was reported as "NO" since Japan had no record of their use in the production of the products. The emission was also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products or refrigerants were refilled.

4.7.1.5. Stationary Air-Conditioning (Household) Production, Use and Disposal (2.F.1.-)

a) Category Description

1) HFCs

HFCs are emitted from the manufacturing, operation, and disposals of household stationary air-conditioning devices.

2) PFCs

Emission from this source in the "production" category was reported as "NO" since Japan had no record of their use in production. The emission was also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products or refrigerants were refilled.

b) Methodological Issues

- ***Estimation Method***

In accordance with the IPCC Guidelines, emissions of each species of F-gases from 1) manufacturing, 2) operation, 3) disposals are estimated, based on production and shipment amounts and amounts of refrigerants charged. Emission factors are country-specific.

Emissions of HFCs from Stationary Air-Conditioning (Household)

1) manufacturing
Emissions from manufacturing = Σ (number of devices produced × amount of refrigerant contained × fugitive refrigerant ratio from manufacturing)
2) operation
Emissions from operation = Σ (number of devices for shipment × average amount of refrigerant contained × fugitive refrigerant ratio from operation
3) disposals
Emissions from disposal = Σ (number of devices disposed × average amount of refrigerant contained) - amount collected
* In the estimation of emissions from operation, the yearly decrease is reflected in the "average amount of refrigerant contained." The "number of devices for shipment" and "number of devices disposed" are estimated from amount of shipment and lifetime of device.

The associated indices are given in the table below.

Table 4-64 Indices related to emissions of HFCs from stationary air-conditioning (household)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced	1,000 devices	NO	NO	1,077	3,981	4,116	4,172	3,970	2,618	3,169	3,155	3,263	3,581	3,076
Refrigerant charged per device	g	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Number of devices operated	1,000 devices	NO	NO	1,726	26,091	33,238	40,356	47,584	53,966	61,540	68,769	75,833	83,349	89,020
Average refrigerant charged during use	g/device	NO	NO	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Fugitive refrigerant ratio during use	%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%
Number of devices disposed	1,000	NO	NO	2	83	142	227	351	524	764	1,075	1,456	1,907	2,423
Average refrigerant stock in device disposed	g/device	NO	NO	954	911	898	884	870	856	841	827	814	803	796
Amount of HFCs collected under law	t/year	-	-	-	10	19	40	67	122	231	264	322	322	466
Emissions	t	NO	NO	38	596	783	981	1,206	1,426	1,675	2,014	2,400	2,883	3,248
	Mt-CO_2 eq.	NO	NO	0.08	1.25	1.64	2.05	2.52	2.98	3.50	4.20	5.01	5.96	6.59

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

For the years 1990 to 1994, it was confirmed that no household stationary air-conditioning with HFCs were used, and therefore emissions for these years are reported as NO. (Ministry of the Environment press release, July 31, 2000, Projections of disposal etc of refrigerant CFCs, HCFCs, and HFCs (Reference material 1))

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.7.1.2.a.c).

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.1.6. Mobile Air-Conditioning Production, Use and Disposal (2.F.1.-)

a) Category Description

1) HFCs

HFCs are emitted from manufacturing, operation, breakdowns, accidents, and disposals of mobile air-conditioning devices.

2) PFCs

Emission from this source in the "production" category was reported as "NO" since Japan had no record of their use in production. The emission was also reported as "NO" in the "use" and "disposal" categories, because it was unlikely that PFCs were used in imported products or refrigerants were refilled.

b) Methodological Issues

- ***Estimation Method***

In accordance with the IPCC Guidelines, emissions of each species of F-gases from 1) manufacturing, 2) operation, 3) breakdowns, 4) accidents and 5) disposals are estimated. Emission factors are country-specific. Emissions from railway and vessel air conditioning are also estimated based on similar methods.

Emissions of HFCs from Mobile Air-Conditioning (Car Air Conditioners)

The below thinking is applied for each type of car:

1) manufacturing
Emissions from manufacturing = Σ (number of devices produced × amount of refrigerant contained × fugitive refrigerant ratio from manufacturing)

2) operation
Emissions from operation = Σ (number of cars operated × amount of refrigerant contained × fugitive refrigerant ratio from operation)

3) breakdowns
Emissions from maintenance =Σ (number of cars operated × amount of refrigerant contained × rate of breakdowns × fugitive refrigerant ratio from breakdowns)

4) accidents
Emissions from accident =Σ (number of cars in completely destroyed × amount of refrigerant contained at time of accident)

5) disposal
(a) until 2001
Emissions from disposal =Σ {number of cars disposed × amount of refrigerant contained × (1 - collection rate) }

(b) from 2002 onward
Emissions from disposal =Σ (number of cars disposed × average amount of refrigerant contained) - amount collected

* In the estimation of emissions from operation, the yearly decrease is reflected in the "amount of refrigerant contained."

Relevant indices are shown in Table below.

Table 4-65 Indices related to emissions of HFC-134a from car air conditioners

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of cars produced	1,000 devices	0	9,745	9,761	10,407	11,074	11,191	11,163	7,653	9,292	8,136	9,856	9,613	9,753
Fugitive refrigirant during production	g	4	4	4	3	3	3	3	1	1	1	1	1	1
Number of cars operated with HFC air conditioners	1,000 devices	0	15,655	42,374	60,364	62,351	63,687	64,543	65,375	66,043	67,366	70,406	70,322	71,316
Average refrigerant charged per device	g	700	700	615	548	536	522	520	497	497	497	497	497	497
Fugitive refrigerant ratio during use per year per device (normal car)	g	15	15	15	10	10	10	10	10	10	10	10	10	10
Rate of breakdown incidences	%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Fugitive refrigerant ratio from breakdown cars	%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Number of cars completely destroyed	1,000 devices	0	50	136	193	200	204	207	209	211	216	225	213	228
Average refrigerant charged in completely destroyed cars	g	681	681	610	522	506	490	475	461	448	439	426	438	408
Number of cars disposed	1,000 devices	0	116	789	2,058	1,471	1,893	2,176	2,498	2,895	2,235	2,709	2,835	2,839
Average refrigerant charged at time of disposal	g	676	676	593	522	484	475	466	456	444	427	404	368	393
Amount of HFC collected (under law from FY2002)	t/year	-	-	-	531	489	604	686	787	898	645	786	785	773
Emissions	t	NO	605	1,759	2,205	1,889	1,944	1,956	1,938	1,952	1,874	1,908	1,822	1,897
	Mt-CO_2 eq.	0.000	0.865	2.516	3.153	2.702	2.780	2.798	2.771	2.791	2.679	2.728	2.605	2.713

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Table 4-66 Indices related to emissions of HFCs from air conditioners (railways)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced	devices	3,208	2,312	1,736	2,012	2,313	2,728	2,240	2,195	1,956	1,807	1,589	1,692	1,645
Refrigerant charged per device at production *	kg	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Number of devices operated	devices	83,635	78,121	72,557	69,295	69,247	67,159	66,890	66,710	66,488	66,004	65,443	65,443	65,443
Refrigerant charged per device during use *	kg	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16	4～16
Fugitive refrigerant ratio during use	%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Emissions from manufacturing	kt-CO_2 eq.	NO	0.003	0.033	0.062	0.070	0.090	0.078	0.081	0.075	0.065	0.052	0.060	0.059
Emissions from stocks	kt-CO_2 eq.	NO	0.710	3.224	13.734	16.945	20.881	23.955	27.336	31.015	34.290	36.833	39.565	42.574
Emissions	kt-CO_2 eq.	NO	0.713	3.256	13.796	17.015	20.971	24.033	27.416	31.090	34.355	36.885	39.625	42.633

Source: Railway Statistical Yearbook, Yearbook of Railway Car Production Statistics, IPCC default values etc. * are from manufacturers.

Table 4-67 Indices related to emissions of HFCs from air conditioners (vessels)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HFC devices produced *	devices	1,993	2,290	1,842	2,546	3,052	3,277	3,367	3,004	2,895	3,424	2,804	2,691	2,755
Refrigerant charged per device at production *	kg	0.4-43.9	0.5-43.4	0.7-40.4	0.6-37.2	0.7-39.0	0.6-38.0	0.7-38.3	0.6-36.7	0.6-39.0	1.1-36.8	1.1-39.9	1.1-37.9	1.1-34.5
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Number of vessels using HFC devices	vessels	11,681	11,267	9,422	8,562	8,468	8,336	8,161	7,919	7,810	7,700	7,680	7,619	7,631
Refrigerant charged per vessel during use *	kg	6-54.9	6-54.7	6-53.6	6-50.8	6-50.4	6-49.8	6-49.4	6-48.8	6-48.6	6-48.2	6-48.07	6-47.9	6-47.7
Fugitive refrigerant ratio during use	%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Number of devices disposed	devices	1,050	348	282	0	3	0	3	6	3	0	0	102	102
Refrigerant stock in device disposed	kg	0-21.9	0-21.9	0-21.9	0-21.9	0-20.8	0-22.3	0-21.3	0-20.1	0-19.2	0-19.2	0-19.8	0-16.6	0-13.2
Collection rate	%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Emissions from manufacturing	kt-CO_2 eq.	NO	NO	0.004	0.070	0.105	0.138	0.199	0.200	0.246	0.264	0.224	0.187	0.178
Emissions from stocks	kt-CO_2 eq.	NO	0.077	0.739	19.384	29.108	40.284	54.787	66.696	80.925	92.989	103.133	110.083	116.936
Emissions from disposal	kt-CO_2 eq.	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.034	0.083
Emissions	kt-CO_2 eq.	NO	0.077	0.743	19.454	29.213	40.423	54.986	66.895	81.171	93.253	103.358	110.305	117.198

Source: IPCC default values, Report on Maritime Affairs. * are based on information from manufacturers.

Due to the lack of data necessary to estimate emissions for the years 1992 to 1994 in which HFCs were used, estimates have been done by using HFC shipment amounts which is thought to be proportional to the number of car produced, and the fugitive refrigerant during production from 1995, average refrigerant charged per device from 1995, fugitive refrigerant ratio during use per year per device (normal car) from 1995, rate of breakdown incidences from 1995, fugitive refrigerant ratio from breakdown cars from 1995, number of cars completely destroyed in 1995, the number of cars operated with HFC air conditioners from 1995, average refrigerant charged in completely destroyed cars from 1995, number of cars disposed from 1995, average refrigerant charged at the time of disposal from 1995, and extrapolating etc for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.7.1.2.b.c).

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

HFC emissions from railway and vessel air conditioning were newly estimated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.2. Foam Blowing Agents (2.F.2.)

4.7.2.1. Closed Cells (2.F.2.-)

4.7.2.1.a. Urethane Foam (2.F.2.-)

a) Category Description

HFC-134a, HFC-245fa, and HFC-365mfc are emitted as a result of foam blowing agent use.

b) Methodological Issues

- ***Estimation Method***

In accordance with the IPCC Guidelines (closed-cell foams), emissions were calculated assuming that 10% of the emission from foam blowing agents used each year occurred within the first year after production, with the remainder emitted over 20 years at the rate of 4.5% per year. The data on the amount of foam blowing agents used each year was provided by the Japan Urethane Foam Association, Japan Urethane Raw Materials Association.

It is difficult to separate the “use” emission from that at the time of “disposal” because urethane foams were disposed of at various times. Accordingly, the emissions in the “use” and “disposal” categories were combined and reported under the “use” category, while the emission in the “disposal” category was reported as “IE”.

Urethane-related HFC emissions
HFC emissions
= Amount of HFC used [t] × Leakage during foam blowing [%]
+ Total amount used upto the previous year [t] × Percentage of annual emissions during use [%]
= (Emissions during production) + (Emissions during use)

Table 4-68 Indices related to emissions of HFC from urethane foam

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-134a use	t	NO	NO	167	224	259	216	145	109	66	65	34	28	14
HFC-245fa use	t	NO	NO	NO	3,893	4,111	4,024	3,044	2,440	2,365	2,597	2,613	2,570	2,533
HFC-365mfc use	t	NO	NO	NO	1311	1492	1401	1122	847	900	960	977	921	866
Leakage during foam blowing	%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Annual emissions rate during use	%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%	4.5%
HFC-134a emissions within the first year after production	t	NO	NO	17	35	33	27	15	11	7	7	3	3	1
HFC-245fa emissions within the first year after production	t	NO	NO	NO	389	411	402	304	244	237	260	261	257	253
HFC-365mfc emissions within the first year after production	t	NO	NO	NO	131	149	140	112	85	90	96	98	92	87
HFC-134a emissions during use	t	NO	NO	NO	44	54	65	75	82	86	89	92	94	95
HFC-245fa emissions during use	t	NO	NO	NO	86	261	446	627	764	874	981	1,097	1,215	1,331
HFC-365mfc emissions during use	t	NO	NO	NO	33	92	159	222	273	311	352	395	439	480
HFC-134a emissions	Mt-CO_2 eq.	NO	NO	0.024	0.112	0.124	0.132	0.128	0.132	0.133	0.137	0.137	0.138	0.138
HFC-245fa emissions	Mt-CO_2 eq.	NO	NO	NO	0.490	0.692	0.874	0.960	1.039	1.144	1.277	1.399	1.516	1.631
HFC-365mfc emissions	Mt-CO_2 eq.	NO	NO	NO	0.130	0.192	0.238	0.266	0.284	0.318	0.355	0.391	0.421	0.450

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, and data provided by the Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

For the years 1990 to 1994, it was confirmed that no urethane foam with HFCs was used, and therefore emissions for these years are reported as NO. (Ministry of the Environment, FY2011 PRTR (Pollutant Release and Transfer Register) “Estimation methods for releases from sources not required to report”)

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emissions for both manufacturing and use, *the 2006 IPCC Guidelines* value of 50% was used.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.2.1.b. Extruded Polystyrene Foam Production (2.F.2.-)

a) Category Description

HFC-134a is emitted as a result of foam blowing agent use.

b) Methodological Issues

- ***Estimation Method***

Emissions were calculated assuming that 25% of the emission of foam blowing agents occurs within the first year after production, with the remainder emitted at the rate of 0.75% per year. The amount of the emissions from foam blowing agents used each year was provided by the Extruded Polystyrene Foam Industry Association. This assumption is consistent with the *2006 IPCC Guidelines* and the estimation method under PRTR for the amount of transferred HCFC at polystyrene foam production

sites.

It is difficult to separate the "use" emission from that at the time of "disposal" because heat insulation material is disposed of at various times such as the renovation and dismantling of buildings, and in times of disaster. Since disposed polystyrene foam is considered to be emitting HFCs as same as that in use, these emissions are combined and reported under "use", while the emissions from "disposal" were reported as "IE".

Extruded polystyrene foam-related HFC-134a emissions

HFC-134a emissions =
Amount of HFC-134a used in particular year [t] × Leakage during foam blowing 25%
+ Total amount used in the past up to the previous year [t] × Annual emission rate during use [%]

Table 4-69 Indices related to emissions of HFC-134a from extruded polystyrene foam

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-134a use	t	NO	NO	NO	26	5	NO	NO	NO	NO	NO	NO	NO	NO
Foam productization rate	%	-	-	-	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Annual emission rate during use	%	-	-	-	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%	0.8%
Emissions during production	t	NO	NO	NO	6.50	1.25	NO	NO	NO	NO	NO	NO	NO	NO
Emissions during use	t	NO	NO	NO	9.00	9.20	9.23	9.23	9.23	9.23	9.23	9.23	9.23	9.23
Emissions	t	NO	NO	NO	15.50	10.45	9.23	9.23	9.23	9.23	9.23	9.23	9.23	9.23
Emissions during production	Mt-CO_2 eq.	NO	NO	NO	0.01	0.00	NO	NO	NO	NO	NO	NO	NO	NO
Emission during use	Mt-CO_2 eq.	NO	NO	NO	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Emissions	Mt-CO_2 eq.	NO	NO	NO	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods etc

For the years 1990 to 1994, it was confirmed that no extruded polystyrene foam with HFCs was used, and therefore emissions for these years are reported as NO. (Ministry of the Environment, FY2011 PRTR "Estimation methods for releases from sources not required to report")

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.7.2.1.a. c).

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.2.2. Open Cells (2.F.2.-)

4.7.2.2.a. High Expanded Polyethylene Foam (2.F.2.-)

a) Category Description

HFC-134a and HFC-152a is emitted as a result of foam blowing agent use.

b) Methodological Issues

- ***Estimation Method***

In accordance with the IPCC Guidelines (open-cell foams), emissions were calculated assuming that all of the emissions from foam blowing agents used occurred at the time of production. The amount of the emissions from foam blowing agents used each year was provided by the High Expanded Polyethylene Foam Industry Association.

Table 4-70 Indices related to emissions of HFC-134a from high expanded polyethylene foam

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-134a use	t	1	346	322	128	120	120	100	98	98	98	98	98	98
Emissions	t	1	346	322	128	120	120	100	98	98	98	98	98	98
	Mt-CO_2 eq.	0.001	0.495	0.460	0.183	0.172	0.172	0.143	0.140	0.140	0.140	0.140	0.140	0.140

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, and data provided by the Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Table 4-71 Indices related to emissions of HFC-152a from high expanded polyethylene foam

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
HFC-152a use	t	0.038	14.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.038	14.000	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Mt-CO_2 eq.	0.000005	0.001736	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic HFC shipment amounts which is thought to be proportional to use amounts of foam blowing agents, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.7.2.1.a. c).

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.3. Fire Protection (2.F.3.)

a) Category Description

HFCs are emitted by the use of halogen fire extinguishers.

b) Methodological Issues

- ***Estimation Method***

HFC-23 and HFC-227ea are used for the productions of fire extinguishers. However, as of 2004, only HFC-227ea is filled in the bottles for fire extinguishing equipment, and each company purchases pre-filled HFC-23 fire extinguisher bottles.

HFCs emission from this category was reported as "NO" by expert judgment since HFC-227ea was a very small amount, 0.0007 [t] (= 700 g) when emission from production in FY2004 was estimated. For use, at the time around 1995, almost no HFC filled fire extinguishers existed on the market, and therefore it is assumed that there was not any use, resulting in NO for 1995 and earlier emissions.

For 1996 and following years, calculations were performed using the following equation and based on the HFC extinguishing agent installations and stocks.

HFC emissions from use of fire extinguishers

HFC emissions [t] = HFC extinguishing agent installations and stocks [t] x Emission factor during use

Concerning the emission at the time of disposal of fire extinguishers, it is reported as "NO" because the use of HFC for fire extinguishers has just started, and also the expected lifetime of buildings is 30-40 years, and therefore they are unlikely to be disposed of as of present.

- ***Emission Factors***

There are still no findings on the emission factor of HFC extinguishing agents when using them. The emission rate (0.00088) determined from refills of halons (provided by the Fire and Disaster Management Agency), which are similar extinguishing agents, was adopted as the emission factor for this category.

Table 4-72 References for the Emission factor of fire extinguishers
(The emission ratio of halon fire extinguishers)

	Unit	2002	2003	2004	2005	2006	2007	Average
Installations of halon 1301 (A)	t	17,094	17,090	17,060	16,994	17,075	16,889	17,034
Refills of halon 1301 (B)	t	13	13	22	13	14	15	15
(B) / (A)		0.00076	0.00076	0.00129	0.00076	0.00082	0.00089	0.00088

- ***Activity Data***

HFC stock amounts provided by the Fire Defense Agency were used as activity data for HFC emissions from fire extinguishing agents use.

Table 4-73 The amounts of the HFC extinguishing agent installations and stocks

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Stocks of HFC-23	t	NO	NO	306	478	481	496	501	512	523	528	533	537	546
HFC-23 emissions	t	NO	NO	0.27	0.42	0.42	0.44	0.44	0.45	0.46	0.46	0.47	0.47	0.48
	kt-CO_2 eq.	NO	NO	3.99	6.23	6.27	6.46	6.52	6.67	6.81	6.87	6.94	6.99	7.11
Stocks of HFC-227ea	t	NO	NO	225	392	421	442	467	498	522	544	596	640	686
HFC-227ea emissions	t	NO	NO	0.20	0.34	0.37	0.39	0.41	0.44	0.46	0.48	0.52	0.56	0.60
	kt-CO_2 eq.	NO	NO	0.64	1.11	1.19	1.25	1.32	1.41	1.48	1.54	1.69	1.81	1.94
Total emissions	kt-CO_2 eq.	NO	NO	4.63	7.34	7.46	7.72	7.85	8.08	8.29	8.42	8.63	8.80	9.06

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emissions, *the 2006 IPCC Guidelines* value of 16% was used.

- ***Time-series Consistency***

Calculations are performed with a method consistently used from FY1995, based on an emission factor and activity data received from the Fire Defense Agency. For years 1990 to 1994, emissions are reported as NO, in light of the fact that HFC filled fire extinguishers were not in use in 1995.

d) Category-specific QA/QC and Verification

See section 4.2.1. d)

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.4. Aerosols (2.F.4.)

4.7.4.1. Metered Dose Inhalers (2.F.4.-)

a) Category Description

HFCs are emitted from the use and disposal of metered dose inhalers (MDIs).

b) Methodological Issues

- ***Estimation Method***

In accordance with the IPCC Guidelines, emissions were calculated on the assumption that from the amount used each year, 50% of the emission occurred in the year of production, with the remaining 50% emitted in the following year.

The amount of purchased gas, the amount of the use of domestically produced MDI, and the use of imported MDI, and the amount of disposal of MDI were provided by the Federation of Pharmaceutical Manufacturers' Associations of Japan (FPMAJ). FPMAJ estimates the amount of HFC disposal by mainly including destructed MDI that were defective products.

F-gas (HFC-134a, HFC-227ea) emissions associated with the manufacturing of MDI

F-gas emissions in year n = Fugitive emissions during manufacturing [t]
＋ F-gas potential emissions in year (n - 1) × 50 [%]
＋ F-gas potential emissions in year n × 50 [%]
- amount of disposal of F-gas contained in MDI

Potential emissions of F-gas = F-gas contained in domestic produced MDI + F-gas contained in imported MDI

The associated indices are given in the table below.

Table 4-74 Indices related to emissions of HFC-134a from MDI

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Purchases of gas	t	NO	NO	1.4	1.1	1.0	0.7	1.1	0.9	1.1	0.9	0.9	0.7	1.1
Usage of domestic MDI	t	NO	NO	1.4	0.9	0.9	0.6	0.9	0.9	1.1	0.8	0.8	0.6	0.9
Usage of imported MDI	t	NO	NO	42.0	70.7	68.6	59.6	61.9	57.1	57.1	54.0	48.3	46.0	42.4
Amount collected and destroyed	t	NO	NO	0.1	1.9	0.3	1.3	0.5	0.4	2.5	2.4	0.8	0.7	0.2
Emissions	t	NO	NO	37.2	62.8	70.4	63.7	61.2	60.0	55.5	54.1	51.3	47.2	44.9
	Mt-CO_2 eq.	NO	NO	0.053	0.090	0.101	0.091	0.088	0.086	0.079	0.077	0.073	0.068	0.064

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, and data provided by the Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Table 4-75 Indices related to emissions of HFC-227ea from MDI

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Purchases of gas	t	NO	NO	NO	42.8	41.2	38.0	48.0	29.3	37.0	32.0	27.3	26.6	21.9
Usage of domestic MDI	t	NO	NO	NO	41.0	39.4	36.2	45.9	27.8	36.0	30.9	25.8	25.1	21.0
Usage of imported MDI	t	NO	NO	3.6	2.1	1.4	0.7	9.0	1.6	0.4	0.8	0.7	0.7	0.4
Amount collected and destroyed	t	NO	NO	NO	1.2	1.5	1.3	1.6	0.9	0.8	0.9	0.8	0.8	0.5
Emissions	t	NO	NO	1.8	48.1	42.3	39.3	46.4	42.8	33.1	34.3	29.8	26.9	23.9
	Mt-CO_2 eq.	NO	NO	0.01	0.15	0.14	0.13	0.15	0.14	0.11	0.11	0.10	0.09	0.08

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, and data provided by the Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

* The production of MDIs using HFC-134a started in 1997, and those using HFC-227ea started in 2001 (with production using imported HFC-227ea starting in 2000).

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, emissions have been estimated to be NO for these years, since for HFC-134a, 1995 and 1996 amounts of usage of domestic MDI and usage of imported MDI are each zero, and for HFC-227ea, 1995 to 1999 amounts of usage of domestic MDI and usage of imported MDI are each zero.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, 0% was applied for all production, use and disposal, due to the fact that the amount of emissions is equal to the amount of MDI used. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all production, use and disposal. As a result, the uncertainties of the emissions for all production, use and disposal were determined to be 10%.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.4.2. Aerosols (2.F.4.-)

a) Category Description

HFCs are emitted from the manufacturing and use of aerosols.

b) Methodological Issues

- ***Estimation Method***

In accordance with the *2006 IPCC Guidelines*, emissions were calculated on the assumption that 50% of the emission from the amount of aerosol filled in the products (potential emissions) occurred in the year of production, with the remaining 50% emitted in the following year. Fugitive emissions from manufacturing is considered as the balance between the amount used for production and the actual measurement amount filled in the products, and it is included in the emissions. The data on the amount used for production and the amount filled in the products were provided by the Aerosol Industry Association of Japan. HFC is considered to be actually remaining in disposed aerosols at some level. However, the amount of emission at the time of "disposal" was reported as "IE" since it is included in the calculation for the "use" category.

HFC emissions associated with the manufacturing of aerosols

HFC emissions in year n = Fugitive emissions during manufacturing [t]
＋ HFC potential emissions in year (n-1) × 50 [%]
＋ HFC potential emissions in year n × 50 [%]

Fugitive emissions during manufacturing = HFC consumed during manufacturing in year n
- HFC potential emissions

The associated indices are given in the table below.

Table 4-76 Indices related to emissions of HFC-134a from aerosols

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Potential emissions	t	NO	1,300	2,044	604	361	307	343	230	200	190	168	168	223
Fugitive emissions during production	t	NO	NO	80	25	14	13	13	10	8	7	8	7	12
Emissions in the year produced, during use	t	NO	650	1,022	302	180	154	172	115	100	95	84	84	112
Remaining (emissions in the next year)	t	NO	650	1,022	302	180	154	172	115	100	95	84	84	112
Emissions	t	NO	1,050	2,137	908	497	347	338	297	223	202	187	175	208
	Mt-CO_2 eq.	NO	1.5	3.1	1.3	0.7	0.5	0.5	0.4	0.3	0.3	0.3	0.3	0.3

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods etc

* Fugitive emissions from 1992 to 1997 are included in potential emissions.

Table 4-77 Indices related to emissions of HFC-152a from aerosols

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Potential emissions	t	NO	NO	34	1,300	1,438	1,193	1,416	764	558	502	542	320	353
Fugitive emissions during production	t	NO	NO	1	29	41	124	381	494	638	730	464	249	185
Emissions in the year produced, during use	t	NO	NO	17	650	719	596	708	382	279	251	271	160	177
Remaining (emissions in the next year)	t	NO	NO	17	650	719	596	708	382	279	251	271	160	177
Emissions	t	NO	NO	18	1,217	1,409	1,439	1,685	1,584	1,299	1,260	986	680	522
	Mt-CO_2 eq.	NO	NO	0.002	0.151	0.175	0.178	0.209	0.196	0.161	0.156	0.122	0.084	0.065

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods etc

* The production of aerosols using HFC-152a started in 2000.

Table 4-78 Indices related to emissions of HFC-245fa from aerosols

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Potential emissions	t	NO	NO	NO	0.795	0.528	0.595	0.667	0.318	0.388	2.034	1.094	0.17	1.1
Fugitive emissions during production	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions in the year produced, during use	t	NO	NO	NO	0.398	0.264	0.298	0.334	0.159	0.194	1.017	0.547	0.085	0.550
Remaining (emissions in the next year)	t	NO	NO	NO	0.398	0.264	0.298	0.334	0.159	0.194	1.017	0.547	0.085	0.550
Emissions	t	NO	NO	NO	0.547	0.662	0.562	0.631	0.493	0.353	1.211	1.564	0.632	0.635
	Mt-CO_2 eq.	NO	NO	NO	0.0006	0.0007	0.0006	0.0006	0.0005	0.0004	0.0012	0.0016	0.0007	0.0007

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the second meeting of the Breakout Group on F-gases, FY2014 Committee for the Greenhouse Gas Emissions Estimation Methods etc

Table 4-79 Indices related to emissions of HFC-365mfc from aerosols

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Potential emissions	t	NO	NO	NO	1.115	1.543	1.476	0.56	NO	NO	NO	0.274	NO	0.244
Fugitive emissions during production	t	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Emissions in the year produced, during use	t	NO	NO	NO	0.558	0.772	0.738	0.280	NO	NO	NO	0.137	NO	0.122
Remaining (emissions in the next year)	t	NO	NO	NO	0.558	0.772	0.738	0.280	NO	NO	NO	0.137	NO	0.122
Emissions	t	NO	NO	NO	0.74	1.329	1.5095	1.018	0.28	NO	NO	0.137	0.137	0.122
	Mt-CO_2 eq.	NO	NO	NO	0.0006	0.0011	0.0012	0.0008	0.0002	NO	NO	0.0001	0.0001	0.0001

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy Trade and Industry, Documents of the second meeting of the Breakout Group on F-gases, FY2014 Committee for the Greenhouse Gas Emissions Estimation Methods etc

The *2006 IPCC Guidelines* specifies estimation methods for HFC-43-10mee emissions from this sub-category, however, emissions do not exceed the 3,000 t-CO_2 eq threshold for estimation, determined by the Committee for Greenhouse Gas Emissions Estimation Methods, and therefore is reported as NE (considered insignificant). (See Annex 5)

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by domestic HFC shipment amounts which are thought to be proportional to potential emissions, and extrapolating etc for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, 0% was applied for all production, use and disposal, due to the fact that the amount of emissions is equal to the amount of aerosols used. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all production, use, and disposal. As a result, the uncertainties of the emissions for all production, use and disposal were determined to be 10%.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

More accurate information became available on HFC-245fa and HFC-365mfc emissions for 2004 and HFC-365mfc emissions for 2012, resulting in recalculations. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.5. Solvents (2.F.5.)

a) Category Description

Liquid HFC-365mfc is used as an industrial dry cleaning solvent by the name of Solkane Dry, and is released into the atmosphere through volatilization etc. HFCs and PFCs are also emitted from the use of solvents for the cleaning of general electronic parts, and semiconductor/liquid crystal manufacturing. The liquid PFCs used were C_5F_{12} (PFC-41-12) and C_6F_{14} (PFC-51-14). Data on HFCs used as solvents in the cleaning of general electronic parts, and semiconductor/liquid crystal manufacturing are confidential; therefore, these are reported as included under the total of PFCs.

b) Methodological Issues

- ***Estimation Method***

  - ***HFCs***

The annual use amount of Solkane Dry is estimated by multiplying the aggregate number of dry cleaning machines using Solkane Dry (from the four domestic manufacturers, and subtracting out the number of machines disposed), by the average solvent amount used. All that is used (=solvent amount replenished) is assumed to have been emitted.

HFC-365mfc emissions

= (aggregate number of dry cleaning machines specialized for Solkane Dry use – machines disposed) x average solvent amount used in specialized machines

+ (aggregate number of dry cleaning machines partially using Solkane Dry – machines disposed) x average solvent amount used in partial-use machines

The average solvent amount used in dry cleaning machines using Solkane Dry is set based on the shipment amounts of Solkane Dry and aggregated number of shipped machines of large manufacturers. (See below) For the average solvent amount used in specialized dry cleaning machines in years 2007 and before, the 2008 value is used. (417kg/machine) For the dry cleaning machines partially using Solkane Dry, the average solvent amount used is set by multiplying the amount for specialized machines by a ratio.

Since there is no shipment of dry cleaning machines using Solkane Dry for 2002 and before,

emissions only start occurring in 2003.

Table 4-80 Number of dry cleaning machines using Solkane Dry and average solvent amount used

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cumulative number of specialized and mixed-use machines	units	0	0	0	12	17	33	48	81	121	171	191	210	225
Average solvent use per year (specialized)	kg/unit	417	417	417	417	417	417	417	719	554	403	567	628	620

➢ ***PFCs***

Assuming that almost all of the total amount of liquid PFC shipment was used in cleaners and for cleaning purposes each year, the entire amount was reported in the ”use” category as the amount of emissions. Emission from manufacturing was reported as ”NO” since there is no practice to blend before use. Emission at the time of disposal was reported as “IE” on the assumption, from the point of view of conservativeness, that the entire amount including that was disposed of, was emitted during use, because of the difficulty in determining the status of the disposal of PFCs. It is confirmed that no disposals were identified in 1995. The associated indices are given in the table below. Emissions from PFCs contained in railway rectifiers (refer to 2.G.2. for details) are subtracted from liquid PFC emissions to yield the total PFC emissions.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic PFC shipment amounts which is thought to be proportional to PFC emissions, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the HFC emission factors, an upper limit value of 30% for the use of electric equipment in the *2006 IPCC Guidelines* was applied. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied. As a result, the uncertainties of the emissions were determined to be 32%.

For the uncertainties of the PFC emission factors, 0% was applied, due to the fact that the amount of emissions is equal to the amount of solvent used. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied. As a result, the uncertainties of the emissions were determined to be 10%.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

The aggregate number of dry cleaning machines specialized for Solkane Dry use for 2013 was revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.7.6. Other applications (2.F.6.)

Refrigerants filled in research and medical equipment are captured and included in other refrigerant categories, and therefore the emissions from this category are reported as "IE", based on expert judgment.

4.8. Other product manufacture and use (2.G.)

This category covers N_2O, PFC, and SF_6 emissions from other product manufacture and use. This section includes GHG emissions from the following sources: Electrical equipment (2.G.1.), Military applications (2.G.2.), Accelerators (2.G.2.), Other – Railway silicon rectifiers (2.G.2.), Medical applications (2.G.3.), and Use during Semiconductor/Liquid Crystal Manufacturing (2.G.3.).

In 2014, emissions from this category were 1,835 kt-CO_2 eq. and represented 0.1% of Japan's total GHG emissions (excluding LULUCF). The total emissions of N_2O from this category had increased by 27.6% compared to 1990. The total of PFCs and SF_6 had decreased by 83.4% compared to 1990.

Table 4-81 Emissions from 2.G. other product manufacture and use

Gas	Emission sub-category			Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N_2O	2.G Other Product Manufacture and Use	2.G.3	Use of N_2O for anesthesia	kt-N_2O	0.93	1.41	1.10	0.86	0.78	0.52	0.42	0.39	0.32	0.31	0.29	0.25	0.25
			Use during semiconductor/liquid crystal manufacturing	kt-N_2O	0.05	0.10	0.15	0.38	0.55	0.61	0.58	0.48	0.60	0.59	0.74	0.95	0.99
	Total			kt-N_2O	0.98	1.51	1.25	1.23	1.33	1.13	1.00	0.87	0.92	0.91	1.03	1.20	1.25
	Total			kt-CO_2 eq.	290.86	448.95	371.30	367.85	395.37	335.54	296.95	259.08	274.93	270.22	307.54	358.79	371.22
Gas	Emission sub-category			Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
PFCs	2.G. Other Product Manufacture	2.G.2	Other-Railway silicon rectifiers	t	NO	NO	NO	0.03	0.07	0.15	0.25	0.34	0.47	0.64	NO	1.11	0.97
SF_6	2.G. Other Product Manufacture and Use	2.G.1	Electrical equipment	t	355.81	460.46	127.62	39.45	42.41	38.59	36.32	31.19	27.29	30.99	31.53	28.19	26.39
		2.G.2	Military applications	t	NO	NO	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
			Accelerators	t	30.77	35.16	34.49	36.81	37.45	37.13	37.07	36.69	34.95	35.26	36.25	36.29	36.18
	Total			t	386.58	495.62	163.34	77.49	81.09	76.95	74.62	69.11	63.48	67.48	69.01	65.71	63.80
Total of F-gases				kt-CO_2 eq.	8814.04	11300.07	3724.20	1767.04	1849.41	1755.87	1703.58	1578.89	1451.58	1544.52	1573.43	1508.47	1463.63

4.8.1. Electrical Equipment (2.G.1.)

a) Category Description

SF_6 are emitted during the manufacturing and use of electrical equipment.

b) Methodological Issues

- ***Estimation Method***

Emissions from producing electrical equipment were calculated by multiplying the amount of SF_6 purchased by assembly fugitive rate. Emissions from the use of electrical equipment were calculated based on the fugitive rate during the use of electrical equipment. Emission factors are country-specific. Emissions from the inspection and disposal of electrical equipment were obtained by actual measurements of SF_6.

In CRF, the emission was reported as "IE" after including the emission from disposal into the use of electrical equipment.

SF_6 emissions from the production of electrical equipment

SF_6 Emissions from the production = SF_6 purchased [t] × assembly fugitive rate [%]

SF_6 emission from the use of electrical equipment

SF_6 emission from the use

= Stocks of SF_6 × rate of emitted SF_6 into the environment during the use of electrical equipment (0.1%)

SF_6 emission from the inspection of electrical equipment

SF_6 emission from the inspection = actual measurements of SF_6

SF_6 emission from the disposal of electrical equipment

SF_6 emission from the disposal = actual measurements of SF_6

The associated indices are given in the table below.

Table 4-82 Indices related to emissions of SF_6 from electrical equipment

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Emissions during manufacturing	Mt-CO_2 eq.	7.05	9.12	2.29	0.52	0.44	0.46	0.42	0.25	0.16	0.17	0.15	0.13	0.14
SF_6 emissions during use, maintenance, and disposal	Mt-CO_2 eq.	1.07	1.38	0.62	0.38	0.53	0.42	0.40	0.46	0.46	0.54	0.57	0.52	0.46

Source: Documents of Fluorocarbons etc Measures Working Group, Group for Chemical Substance Policy, Manufacturing Industries Sub-Group, Industrial Structure Council, Ministry of Economy, Trade and Industry, and data provided by the Ministry of Economy, Trade and Industry, Documents of the first meeting of the Breakout Group on F-gases, FY2013 Committee for the Greenhouse Gas Emissions Estimation Methods

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic SF_6 shipment amounts which is thought to be proportional to amounts of SF_6 purchased and stocks of SF_6, amounts of SF_6 charged to electrical equipment from 1995, the assembly fugitive rate from 1995, and the operational fugitive rate from 1995, and extrapolating for these years.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, -30 - +30% was applied for manufacturing and use, and -20 - +40% was applied for disposal, in accordance with the*2006 IPCC Guidelines'* default value. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied for all manufacturing, use, and disposal. As a result, the uncertainty of the emissions for manufacturing and use was determined to be -32 - +32%, and -22 - +41% for disposal.

- ***Time-series Consistency***

See section 4.3.9.1. c).

d) Category-specific QA/QC and Verification

See section 4.3.9.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.8.2. SF_6 and PFCs from other product use (2.G.2.)

4.8.2.1. Military applications (2.G.2.-)

a) Category Description

SF_6 is used as an insulating medium in the radar systems of AWACS (Airborne Warning and Control System). When the plane ascends, SF_6 is automatically released from the system and into the atmosphere to maintain the appropriate pressure difference between the system and the outside air. When the plane descends, SF_6 is automatically charged into the system from an SF_6 container on board.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated using a method corresponding to the Tier 2 method (user mass-balance method) in the *2006 IPCC Guidelines*.

SF_6 Emissions = Decrease of SF_6 in the container on board the AWACS

+ SF_6 leakage during acquisition/replacement of SF_6 container on AWACS

- SF_6 collected/destroyed – Net increase in AWACS fleet charge

The four-fleet AWACS was officially authorized for use on March 24, 1999, and therefore SF_6 emissions are considered to have started in 1999.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

No emission factor is set, and therefore the uncertainty of emissions is assessed by assessing the uncertainty of activity data. A 10% uncertainty of metal production is taken for the uncertainty of activity data. As a result, the uncertainty of emissions is 10%.

- ***Time-series Consistency***

Emissions are estimated in a manner consistent across the time-series methodologically, and from the point of view of data source.

d) Category-specific QA/QC and Verification

See section 4.2.1. d）.

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.8.2.2. Accelerators (2.G.2.-)

a) Category Description

SF_6 is used in university and research facility-operated particle accelerators, and in industrial/medical accelerators (for cancer therapy) as an insulating gas. When the equipment requires maintenance, the SF_6 is transferred into storage tanks, and therefore losses occur primarily during gas transfer.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated using the Tier 1 method in the 2006 IPCC Guidelines.

SF_6 Emissions = (Number of accelerators) × (SF_6 use factor) × (SF_6 charge factor) × (SF_6 emission factor)

The SF_6 use factor, SF_6 charge factor, SF_6 emission factor, and number of accelerators used for estimating emissions are shown below by type of accelerator.

Table 4-83 SF_6 use factor, SF_6 charge factor, SF_6 emission factor by type of accelerator

Item	University and research operated particle accelerators	Industrial particle accelerators	Medical particle accelerators*	Small-scale electron accelerators
SF_6 use factor	33%	100%	100%	100%
SF_6 charge factor	2,400kg	1,300kg	0.5kg	400kg **
SF_6 emission factor	0.07kg/kg	0.07kg/kg	2.0kg/kg	0.07kg/kg

* Among the medical particle accelerators, cyclotrons and synchrotrons are not considered to use SF_6, and therefore are not estimated for.

(Source) 2006 IPCC Guidelines default values excluding the ** value. ** value: Results of interviews with main accelerator manufacturers.

Table 4-84 Number of accelerators by type

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of particle accelerators (University/Research facilities)	188	214	212	209	216	207	214	219	218	216	231	225	225
Number of particle accelerators (Industrial use)	143	164	145	181	184	187	186	181	174	179	184	188	188
Number of particle accelerators (Medical use)	531	641	754	857	874	905	922	936	926	986	1028	1068	1068
Number of small-scale (below 1MeV) electron accelerators	243	276	314	282	280	276	263	255	218	215	203	201	197

(Source) *Statistics on the Use of Radiation in Japan* (Japan Radioisotope Association), except for the *Nuclear Yearbook* (The Japan Atomic Industrial Forum) etc for small-scale electron accelerators

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the EF, a -50 - +400% uncertainty from the 2006 IPCC Guidelines (particle accelerators - medical use) was applied. A -10 - +10% uncertainty of metal production is taken for the uncertainty of activity data. As a result, the uncertainty of emissions is -51 - +400%.

- ***Time-series Consistency***

Emissions are estimated in a manner consistent across the time-series methodologically, and from the point of view of data source.

d) Category-specific QA/QC and Verification

See section 4.2.1. d）.

e) Category-specific Recalculations

The method to estimate the number of small-scale electron accelerators for 2005 onward was revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

4.8.2.3. Soundproof windows (2.G.2.-)

The *2006 IPCC Guidelines* specifies estimation methods for this this sub-category, however, emissions do not exceed the 3000 t-CO_2 eq threshold for estimation, determined by the Committee for Greenhouse Gas Emissions Estimation Methods, and therefore is reported as NE (considered insignificant). (See Annex 5)

4.8.2.4. Adiabatic properties: shoes and tyres (2.G.2.-)

PFC and SF_6 use for rubber with adiabatic properties are not found in Japan, and therefore emissions are reported as NO.

4.8.2.5. Other - Railway Silicon Rectifiers (2.G.2.-)

a) Category Description

PFCs are emitted at disposal of railway silicon rectifiers.

b) Methodological Issues

- ***Estimation Method***

Based on the number of devices containing PFC-51-14, the amount of PFC-51-14 contained, and lifetime of the devices installed on ground and on car respectively, given in the Survey on Management Methods of Halons/Liquid PFCs etc (2006), and the Survey on Destruction of Halons/PFCs etc (2010), the amount of PFC-51-14 disposed after use in railway silicon rectifiers in each fiscal year was estimated. This was done by multiplying the number of railway silicon rectifiers disposed per year, by the amount of PFC contained in each device. PFC emissions are calculated by subtracting the amount of PFC-51-14 destroyed in a specific fiscal year from the PFC disposed after use in railway silicon rectifiers in the same fiscal year.

PFC emissions at disposal of railway silicon rectifiers
= PFC disposed after use in railway silicon rectifiers - PFC destroyed

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor from railway silicon rectifiers, the 0% value for solvents was applied since it is a similar source category. For the uncertainties of the activity data, the 10% value of the Tier 2 method for metal industry in the *2006 IPCC Guidelines* was applied. As a result, the uncertainties of the emissions were determined to be 10%.

- ***Time-series Consistency***

Emissions are estimated in a manner consistent across the time-series methodologically, and from the point of view of data source.

d) Category-specific QA/QC and Verification

See section 4.2.1. d）.

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

No improvements are planned.

4.8.3. N_2O from product uses (2.G.3.)

4.8.3.1. Medical applications (2.G.3.a)

a) Category Description

Nitrous oxide is emitted during anesthetics (laughing gas) use. Since 2006, some hospitals have installed N_2O destruction units, and the reductions achieved are reflected in the total emissions. CO_2 is not used as an anesthetic in Japan, and therefore CO_2 emissions have been reported as “NA”.

a) Methodological Issues

- ***Estimation Method***

In relation to emissions of N_2O from use of anesthetics, the actual amount of N_2O shipped as an anesthetic by pharmaceutical manufacturers or importers has been reported for 2005 and preceding years. For 2006 and beyond, the amount of N_2O collected is calculated using the amount of laughing gas used in domestic hospitals equipped with N_2O destruction units for anesthesia, and a destruction rate of 99.9 %. This is subtracted from the N_2O shipped for medical use to yield the amount of N_2O emitted.

Amount of N_2O emitted during the use of laughing gas
= N_2O shipped for medical use
− Amount of laughing gas used in hospitals equipped with N_2O destruction units × destruction rate

- ***Emission Factors***

It is assumed that all of the N_2O used as medical gas escapes into the atmosphere, unless collected. Therefore, no emission factor has been established.

- ***Activity Data***

The volume of shipments of N_2O for anesthetics (on calendar year basis) is given in the Ministry of Health, Labour and Welfare's *Statistics of Production by Pharmaceutical Industry*. This is used for 2005 and preceding years, and for 2006 to 2009, the amount of N_2O collected in three, and from 2010 and onward collected in four domestic hospitals equipped with N_2O destruction units is subtracted from the above-mentioned shipment.

Table 4-85 Laughing gas shipment amount and N_2O collected in domestic hospitals

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Laughing gas shipment amount	kg-N_2O	926,030	1,411,534	1,099,979	859,389	789,558	519,011	417,919	389,749	320,110	314,155	292,971	253,218	253,218
N_2O collected in domestic hospitals	kg-N_2O	-	-	-	-	7,822	3,042	1,454	1,049	914	779	450	509	0

b) Uncertainties and Time-series Consistency

- ***Uncertainty***

Because all N_2O used for anesthetics are assumed to escape into the atmosphere, no emission factor has been set. Therefore, the uncertainty for activity data is also the uncertainty for emissions. As *Statistics of Production by Pharmaceutical Industry* is a fundamental statistic based on statistical law, a 5% uncertainty was given for this emission source.

- ***Time-series Consistency***

The volumes of shipments are taken from the *Statistics of Production by Pharmaceutical Industry* in a consistent manner throughout the time series.

c) Category-specific QA/QC and Verification

See section 4.2.1. d).

d) Category-specific Recalculations

The N_2O shipment amount was revised for 2013. See Chapter 10 for impact on trend.

e) Category-specific Planned Improvements

No improvements are planned.

4.8.3.2. Other (2.G.3.b)

4.8.3.2.a. Use during Semiconductor/Liquid Crystal Manufacturing (2.G.3.b.-)

a) Category Description

N_2O is used as an oxidizing agent to form an insulative oxide film during semiconductor/liquid crystal

manufacturing, and the remaining is considered to be released into the atmosphere.

b) Methodological Issues

- ***Estimation Method***

Emissions equal all N_2O shipment amounts for semiconductor/liquid crystal manufacturing.

N_2O emissions during semiconductor/liquid crystal manufacturing

= N_2O shipped for semiconductor/liquid crystal manufacturing use

- ***Emission Factors***

Emissions equal activity data, and therefore no emission factor has been established.

- ***Activity Data***

The N_2O shipment amounts for semiconductor/liquid crystal manufacturing reported by the Japan Industrial and Medical Gases Association is used as activity data.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

Because all N_2O used during semiconductor/liquid crystal manufacturing are assumed to escape into the atmosphere, no emission factor has been set. Therefore, the uncertainty for activity data is also the uncertainty for emissions. For the uncertainty of activity data, a 5% default value in the *2006 IPCC Guidelines* were used.

- ***Time-series Consistency***

The shipment amounts are taken from what is reported by the Japan Industrial and Medical Gases Association in a consistent manner throughout the time series.

d) Category-specific QA/QC and Verification

See section 4.2.1. d).

e) Category-specific Recalculations

There have been no source-specific recalculations.

f) Category-specific Planned Improvements

There is a possibility of over-estimation, since emissions are equal to all N_2O shipment amounts for semiconductor/liquid crystal manufacturing.

4.9. Other (2.H.)

4.9.1. Food and beverages industry (2.H.2.)

The CO_2 recovered, estimated together with the emissions from ethylene oxide production (2.B.8.-.) is reported here.

Petroleum refining plants, ammonia production plants, and iron production plants are other sources of supply CO_2 for the production of carbonated gas and dry ice in Japan, however those emissions occurring from petroleum refining plants are reported under the Fuel combustion sector (1.A.), and those emissions occurring from ammonia production plants are reported under ammonia production (2.B.1.), and those emissions occurring from iron production plants are reported under the Fuel combustion sector (1.A.).

Table 4-86 Emissions from the food and beverages industry

Gas	Emission sub-category			Units	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	2.H Other	2.H.2	Food and beverages industry	kt-CO_2	64.27	71.54	86.50	90.05	87.52	86.16	71.55	71.29	75.85	75.81	76.41	82.33	80.44

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Chapter 5. Agriculture (CRF sector 3)

5.1. Overview of Sector

Greenhouse gas emissions from the agricultural sector are calculated in seven categories: 3A, 3B, 3C, 3D, 3F, 3G, and 3H. In 3A: Enteric Fermentation, CH_4 gas generated and emitted by cattle, buffalo, sheep, goats, horses, and swine as the result of enteric fermentation is reported. In 3B: Manure Management, CH_4 and N_2O generated by treatment of manure excreted by cattle, buffalo, sheep, goats, horses, swine, poultry (hen and broiler), rabbit, and mink are reported. In 3C: Rice Cultivation, CH_4 emissions from paddy fields (continuously flooded and intermittently flooded) cultivated for rice production are reported. In 3D: Agricultural Soils, N_2O emitted directly and indirectly from agricultural soil are reported. Emissions for 3E Prescribed Burning of Savannas are reported as NO, since Japan has no emission source in this category, while CH_4 and N_2O (as well as CO and NO_X, which is described in Annex 3) emissions from field burning of grains, legumes, root crops, and sugar cane during agricultural activities are reported in 3F: Field Burning of Agricultural Residues. 3G and 3H: Liming and Urea Application, CO_2 emissions by application of limestone and urea to soil are reported.

GHG emissions in the agricultural sector in FY2014 were 38,372 kt-CO_2 eq., comprising 2.8% of total emissions (excluding LULUCF). The value represents a reduction by 8.6% from FY1990.

Tier of methodology used in Agriculture sector are showed in Table 5-1.

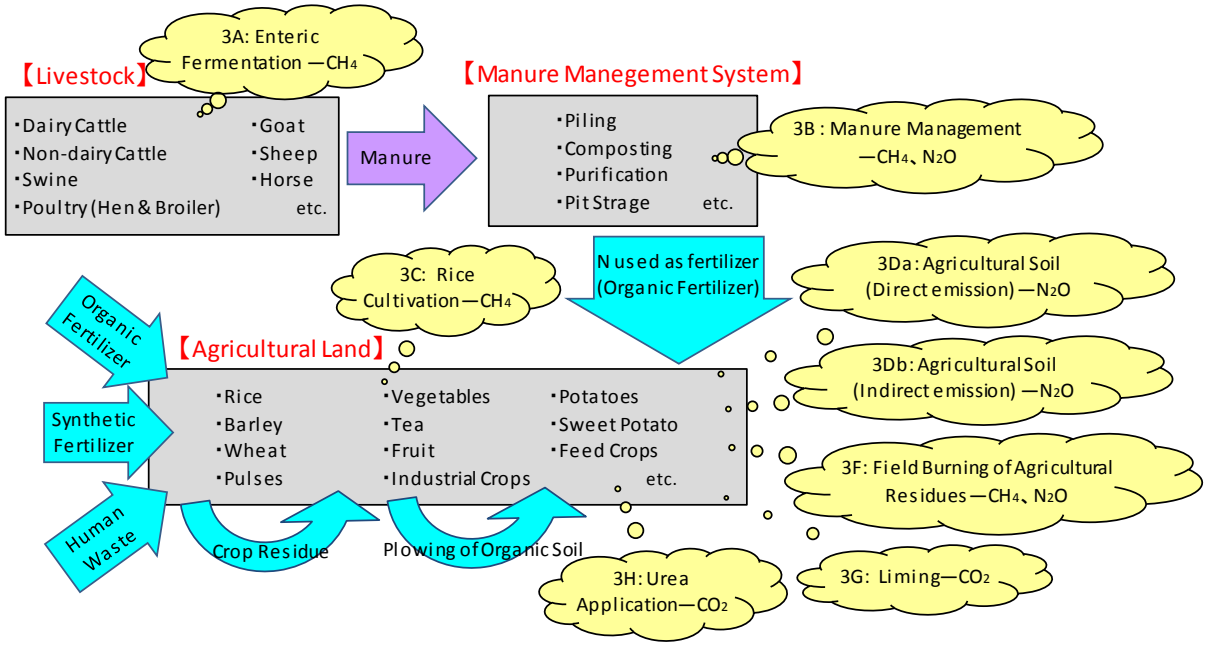

Figure 5-1 Relationships among the categories in the agricultural sector

Table 5-1 Tier of methodology used in Agriculture sector

GREENHOUSE GAS CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
3.A. Enteric fermentation			CS,T1	CS,D		
3.B. Manure management			CS,T1	CS,D	CS,T1	CS,D
3.C. Rice cultivation			T3	CS		
3.D. Agricultural soils					CS,T2	CS,D
3.F. Field burning of agricultural residues			T1	D	T1	D
3.G. Liming	T1	D				
3.H. Urea application	T1	D				

D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country-specific method or emission factor

5.2. Enteric Fermentation (3.A.)

Ruminants such as cattle, buffalo, sheep, and goats have multi-chamber stomachs. The rumen carries out anaerobic fermentation to decompose cellulose and other substances, thereby releasing CH_4. Horses and swine are not ruminants and have monogastric stomachs, but fermentation in their digestive tracts produces small amounts of CH_4, which is released into the atmosphere. These CH_4 emissions are calculated and reported in the Enteric Fermentation (3.A.) section.

GHG emissions from enteric fermentation in FY2014 were 7,223 kt-CO_2 eq., comprising 0.5% of total emissions (excluding LULUCF). The value represents a reduction by 20.3% from FY1990. Main driver of the emission reduction from FY1990 is a reduction of cattle population.

Table 5-2 CH_4 emissions from enteric fermentation

Gas	Livestock species	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	3.A.1.- Dairy cattle	kt-CH_4	186.1	179.3	166.5	158.8	157.1	153.7	150.4	148.1	144.9	145.1	142.3	138.6	136.0
	3.A.1.- Non-dairy cattle	kt-CH_4	158.2	164.2	165.0	157.5	159.8	163.9	162.3	160.2	152.9	151.4	146.8	142.4	138.0
	3.A.2. Sheep	kt-CH_4	0.167	0.115	0.097	0.071	0.077	0.082	0.097	0.113	0.119	0.125	0.131	0.138	0.138
	3.A.3. Swine	kt-CH_4	15.9	13.9	13.7	13.5	13.7	13.6	13.9	13.8	13.7	13.6	13.6	13.4	13.4
	3.A.4.- Buffalo	kt-CH_4	0.011	0.007	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.006
	3.A.4.- Goats	kt-CH_4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	3.A.4.- Horses	kt-CH_4	2.1	2.1	1.9	1.6	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.3	1.3
	Total	kt-CH_4	362.6	359.7	347.3	331.5	332.2	332.8	328.2	323.8	313.1	311.7	304.2	295.9	288.9
		kt-CO_2eq	9,064	8,993	8,682	8,287	8,305	8,320	8,204	8,094	7,829	7,793	7,606	7,399	7,223

5.2.1. Cattle (3.A.1.)

a) Category Description

This section provides the estimation methods for CH_4 emissions from enteric fermentation in Cattle.

b) Methodological Issues

- ***Estimation Method***

In accordance with decision tree of the *2006 IPCC Guidelines* (Volume 4, Page 10.25, Fig.10.2), calculations for dairy and non-dairy cattle should be performed using the Tier 2 method. In the Tier 2 method, emission factors are calculated by multiplying the total energy intake of livestock by the CH_4 conversion factor. However, estimation using amount of dry matter intake has been practiced in Japan on livestock-related research. It is considered that, by applying the results of previous researches, the estimation method using amount of dry matter intake provides more accurate results. For that reason, a technique similar to the Tier 2 method but specific to Japan was used for the calculation of CH_4

emissions associated with enteric fermentation by cattle. The emissions were calculated by multiplying the cattle population (dairy and non-dairy) by the emission factors established based on their dry matter intake.

$$E = \sum \left(EF_i \times A_i \right)$$

E : CH_4 emissions from enteric fermentation for cattle [kg-CH_4]
EFi : CH_4 Emission factor of enteric fermentation of cattle type *i* [kg-CH_4 /head]
Ai : Cattle population of cattle type *i* [head]

As cattle begin to eat normal feed at the age of five to six months, the calculation of the CH_4 emissions associated with enteric fermentation includes cattle aged five months or older (cattle under five months are excluded from estimation). To reflect the actual situation of emissions in Japan, categorization of cattle is defined as shown below, and CH_4 emissions is estimated by type and age.

Table 5-3 Categorization and assumptions underlying calculation of CH_4 emissions associated with enteric fermentation in cattle

Animal type				Assumptions for calculation of emissions	Additional information for each animal type
Dairy cattle	Lactating			−	Lactating cattle.
	Non-lactating			−	Cattle of non-lactating period at present.
	Heifers	Under 2 years old and over 6 months old		Calculation excludes 6/24 of the population which was assumed to be 6 months old or younger; therefore actually covering only 18/24 of the population under 2 years old.	Cattle for lactating, which are under 2 years old. Population of under 2 years old are descried in the *Livestock Statistics*.
		5 and 6 months old		Calculation covers 5- and 6-month old comprising 2/24 of the population under 2 years old.	
		Under 5 months old		Covering 4/24 of the population under 2 years old. Excluded from CH_4 emission estimation.	
Non-dairy cattle	Breeding cows	1 year old and over		−	Breeding cow excluding dairy breeds. Population of under 1 year old are descried in the *Livestock Statistics*.
		Under 1 year old and over 6 months old		Calculation excludes 6/12 of the population which was assumed to be 6 months old or younger; therefore covering 6/12 of the population under 1 year old.	
		5 and 6 months old		Calculation covers 5- and 6-month old comprising 2/12 of the population under 1 year old.	
		Under 5 months old		Covering 4/12 of the population under 1 year old. Excluded from CH_4 emission estimation.	
	Fattening cattle	Japanese cattle	1 year old and over	−	Cattle of native breeds in Japan called "Wagyu", which breeds are served for meat only. Population of under 1 year old are descried in the *Livestock Statistics*.
			Under 1 year old and over 6 months old	Calculation excludes 6/12 of the population which was assumed to be 6 months old or younger; therefore covering 6/12 of the population under 1 year old.	
			5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/12 of the population under 1 year old.	
			Under 5 months old	Covering 4/12 of the population under 1 year old. Excluded from CH_4 emission estimation.	
		Dairy breeds	Over 6 months old	Calculation excludes 6/24 of the population which was assumed to be 6 months old or younger; therefore covering 18/24 of the population under 2 years old.	Cattle of dairy breeds for meat such as Holsteins. Population of under 2 years old are descried in the *Livestock Statistics*.
			5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/24 of the population under 2 years old.	
			Under 5 months old	Covering 4/24 of the population under 2 years old. Excluded from CH_4 emission estimation.	

- ***Emission Factors***

The emission factor for CH_4 associated with enteric fermentation in cattle has been established on the basis of breath testing of ruminant livestock in Japan; it is based on the measured data for volume of CH_4 per dry matter intake. Results of measurements have made it clear that it is possible to estimate CH_4 from enteric fermentation in ruminant livestock using the equation given below, which uses dry

matter intake as the explanatory variable (Shibata et al. (1993), Reference 24).

$$EF = Y / L_{CH4} \times Mol_{CH4} \times Day$$

$$Y = -17.766 + 42.793 \times DMI - 0.849 \times (DMI)^2$$

EF : CH_4 emission factor associated with enteric fermentation in cattle [kg-CH_4/head]
Y : Volume of CH_4 generated per head per day [l/day/head]
L_{CH4} : Volume of 1 mol CH_4 [l/mol] (=22.4)
Mol_{CH4} : Molecular weight of CH_4 [kg/mol] (=0.016)
Day : Days in a year [day] (=365 or 366)
DMI : Dry matter intake [kg/day/head]

Average dry matter intake estimated from Japan Feed Standards compiled by the Japan Livestock Industry Association was applied to the above equation to establish emission factors. The dry matter intake was calculated by substituting fat corrected milk, body weight, and weight gain by daily growth into the equation established for each type of cattle. Data for the fat corrected milk was obtained from the *Statistics on Milk and Dairy Products* (Ministry of Agriculture, Fisheries and Forestry; MAFF) and the *Statistics on Livestock* (MAFF), and those for the fat content in milk from the *Statistics of Livestock Production Costs* (MAFF). Both sets of the data are updated on a yearly basis. Data for body weight and weight gain by daily growth were obtained from the table of weight by age (months) for each type of cattle included in the *Japanese Feeding Standards* (Japan Livestock Industry Association). Equations to estimate dry matter intake were revised in 2006 for dairy cattle (lactating and non-lactating) and in 2008 for non-dairy cattle (Japanese cattle(M)).

Table 5-4 Equation to estimate dry matter intake (DMI) by cattle

Animal type		Equation
Dairy cattle	Lactating	After 2006: $DMI=1.3922+0.05839 \times W^{0.75}+0.40497 \times FCM$ $FCM=(15 \times FAT/100+0.4) \times MILK$ Before 2005: $DMI=2.98120+0.00905 \times W+0.41055 \times FCM$ $FCM=(15 \times FAT /100+0.4) \times MILK$
	Non-lactating	After 2006: $DMI=0.017 \times W$ Before 2005: $DMI=(0.1163 \times W^{0.75}/0.82)/4.41/0.52 \times 1.1$
	Heifers	$DMI=0.49137+0.01768 \times W+0.91754 \times DG$
Non-dairy cattle	Breeding cows	$DMI= [0.1067 \times W^{0.75} +(0.0639 \times W^{0.75} \times DG)/(0.78 \times q+0.006)]/(q \times 4.4)$ $q=0.4213+0.1491 \times DG$
	Japanese cattle (M)	After 2008: $DMI=-3.481+2.668 \times DG+4.548 \times 10^{-2} \times W-7.207 \times 10^{-5} \times W^2+3.867 \times 10^{-8} \times W^3$ Before 2007: $DMI= [0.1124 \times W^{0.75}+(0.0546 \times W^{0.75} \times DG)/(0.78 \times q+0.006)]/\{q \times (1.653-0.00123 \times W)\}$ $q=0.5304+0.0748 \times DG$
	Japanese cattle (F)	$DMI=[0.1108 \times W^{0.75}+(0.0609 \times W^{0.75} \times DG)/(0.78 \times q+0.006)]/(q \times 4.4)$ $q= 0.5018+0.0956 \times DG$
	Dairy breeds (over 6 months old)	$DMI=[0.1291 \times W^{0.75}+(0.0510 \times W^{0.75} \times DG)/(0.78 \times q+0.006)]/(q \times 4.4)$ $q=(0.933+0.00033 \times W) \times (0.498+0.0642 \times DG)$
	Dairy breeds (5 and 6 months old)	$DMI=[0.1291 \times W^{0.75}+\{(1.00+0.030 \times W^{0.75}) \times DG\}/(0.78 \times q+0.006)]/(q \times 4.4)$ $q=(0.859-0.00092 \times W) \times (0.790+0.0411 \times DG)$

W: Weight, FCM: Fat Corrected Milk, FAT: Fat content in milk, MILK: Milk Yield, DG: Daily Growth, q: Energy metabolic rate
Source: Japan Livestock Industry Association, *Japan Feed Standards* (Reference 20)

Table 5-5 Fat content in milk (FAT) and milk yield (MILK) by cattle

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Milk yield (Lactating)	20.8	22.4	23.5	25.1	25.0	25.4	25.5	25.7	25.6	25.5	25.8	26.0	26.4
Fat content in milk (Lactating)	3.7	3.8	3.9	4.0	4.0	4.0	4.0	3.9	3.9	3.9	3.9	3.9	3.9

Table 5-6 Weight by cattle (W) [kg head^{-1}]

Animal Type			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle		Lactating	595.9	602.8	621.4	622.7	623.0	623.0	623.0	623.0	623.0	623.0	623.0	623.0	623.0
		Non-lactating	595.9	602.8	621.4	622.7	623.0	623.0	623.0	623.0	623.0	623.0	623.0	623.0	623.0
		Heifer: under 2 yr, over 6 mth	342.4	349.3	364.9	374.2	376.1	376.1	376.1	376.1	376.1	376.1	376.1	376.1	376.1
		Heifer: 5 and 6 mth	140.0	140.6	146.3	162.8	166.1	166.1	166.1	166.1	166.1	166.1	166.1	166.1	166.1
Non-dairy cattle	Breeding	1 yr and over	426.6	426.6	487.3	450.9	443.7	436.4	429.1	429.1	429.1	429.1	429.1	429.1	429.1
		Under 1 yr, over 6 mth	230.2	230.2	279.7	259.3	255.2	251.1	247.0	247.0	247.0	247.0	247.0	247.0	247.0
		5 and 6 mth	141.0	141.0	157.1	146.8	144.8	142.8	140.7	140.7	140.7	140.7	140.7	140.7	140.7
	Fattening cattle	Japanese cattle (M): 1 yr and over	574.3	574.3	574.3	572.3	571.9	571.4	571.0	571.0	571.0	571.0	571.0	571.0	571.0
		Japanese cattle (M): under 1 yr, over 6 mth	273.4	273.4	273.4	274.6	274.9	275.1	275.4	275.4	275.4	275.4	275.4	275.4	275.4
		Japanese cattle (M): 5 and 6 mth	146.7	146.7	146.7	147.9	148.1	148.4	148.6	148.6	148.6	148.6	148.6	148.6	148.6
		Japanese cattle (F): 1 yr and over	388.0	388.0	462.5	427.7	420.7	413.8	406.8	406.8	406.8	406.8	406.8	406.8	406.8
		Japanese cattle (F): under 1 yr, over 6 mth	230.2	230.2	279.7	259.3	255.2	251.1	247.0	247.0	247.0	247.0	247.0	247.0	247.0
		Japanese cattle (F): 5 and 6 mth	141.0	141.0	157.1	146.8	144.8	142.8	140.7	140.7	140.7	140.7	140.7	140.7	140.7
		Dairy breed: over 6 mth	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8	479.8
		Dairy breed: 5 and 6 mth	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8

Table 5-7 Daily growth by cattle (DG) [kg head^{-1} day^{-1}]

Animal Type			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle		Lactating	—	—	—	—	—	—	—	—	—	—	—	—	—
		Non-lactating	—	—	—	—	—	—	—	—	—	—	—	—	—
		Heifer: under 2 yr, over 6 mth	0.60	0.63	0.65	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
		Heifer: 5 and 6 mth	0.69	0.70	0.76	0.88	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Non-dairy cattle	Breeding	1 yr and over	0.17	0.17	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
		Under 1 yr, over 6 mth	0.70	0.70	0.94	0.86	0.84	0.83	0.81	0.81	0.81	0.81	0.81	0.81	0.81
		5 and 6 mth	0.74	0.74	1.04	0.96	0.94	0.92	0.91	0.91	0.91	0.91	0.91	0.91	0.91
	Fattening cattle	Japanese cattle (M): 1 yr and over	0.60	0.60	0.60	0.59	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
		Japanese cattle (M): under 1 yr, over 6 mth	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
		Japanese cattle (M): 5 and 6 mth	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
		Japanese cattle (F): 1 yr and over	0.28	0.28	0.27	0.25	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
		Japanese cattle (F): under 1 yr, over 6 mth	0.70	0.70	0.94	0.86	0.84	0.83	0.81	0.81	0.81	0.81	0.81	0.81	0.81
		Japanese cattle (F): 5 and 6 mth	0.74	0.74	1.04	0.96	0.94	0.92	0.91	0.91	0.91	0.91	0.91	0.91	0.91
		Dairy breed: over 6 mth	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
		Dairy breed: 5 and 6 mth	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10

Table 5-8 Dry matter intake by cattle (DMI) [kg head^{-1} day^{-1}]

Animal Type			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle		Lactating	16.6	17.4	18.1	18.9	18.7	18.9	18.9	19.0	18.9	18.9	19.0	19.0	19.2
		Non-lactating	8.2	8.3	8.5	8.5	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6
		Heifer: under 2 yr, over 6 mth	7.1	7.2	7.5	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7	7.7
		Heifer: 5 and 6 mth	3.6	3.6	3.8	4.2	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Non-dairy cattle	Breeding	1 yr and over	6.6	6.6	7.1	6.6	6.5	6.4	6.3	6.3	6.3	6.3	6.3	6.3	6.3
		Under 1 yr, over 6 mth	5.5	5.5	6.7	6.2	6.1	6.0	5.9	5.9	5.9	5.9	5.9	5.9	5.9
		5 and 6 mth	3.8	3.8	4.4	4.1	4.1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
	Fattening cattle	Japanese cattle (M): 1 yr and over	8.4	8.4	8.4	8.3	8.3	8.3	7.7	7.7	7.7	7.7	7.7	7.7	7.7
		Japanese cattle (M): under 1 yr, over 6 mth	6.8	6.8	6.8	6.8	6.8	6.8	7.2	7.2	7.2	7.2	7.2	7.2	7.2
		Japanese cattle (M): 5 and 6 mth	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4
		Japanese cattle (F): 1 yr and over	5.7	5.7	6.4	6.0	5.9	5.8	5.7	5.7	5.7	5.7	5.7	5.7	5.7
		Japanese cattle (F): under 1 yr, over 6 mth	4.9	4.9	6.1	5.6	5.5	5.4	5.3	5.3	5.3	5.3	5.3	5.3	5.3
		Japanese cattle (F): 5 and 6 mth	3.4	3.4	4.1	3.8	3.7	3.7	3.6	3.6	3.6	3.6	3.6	3.6	3.6
		Dairy breed: over 6 mth	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
		Dairy breed: 5 and 6 mth	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3

Table 5-9 Emission factor associated with enteric fermentation by cattle [kg-CH_4 $head^{-1}$ yr^{-1}]

Animal Type			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle		Lactating	119.5	122.8	124.9	127.1	126.7	127.5	127.3	127.4	127.1	127.5	127.4	127.5	127.9
		Non-lactating	72.0	72.7	74.0	74.1	88.7	88.9	88.7	88.7	88.7	88.9	88.7	88.7	88.7
		Heifer: under 2 yr, over 6 mth	63.4	64.7	66.9	67.8	68.0	68.1	68.0	68.0	68.0	68.1	68.0	68.0	68.0
		Heifer: 5 and 6 mth	32.7	32.9	34.4	38.1	38.8	38.9	38.8	38.8	38.8	38.9	38.8	38.8	38.8
Non-dairy cattle	Breeding	1 yr and over	59.0	59.2	63.1	59.3	58.5	57.9	57.0	57.0	57.0	57.1	57.0	57.0	57.0
		Under 1 yr, over 6 mth	49.8	50.0	60.1	56.3	55.5	54.8	53.8	53.8	53.8	54.0	53.8	53.8	53.8
		5 and 6 mth	34.9	35.0	40.4	37.8	37.3	36.9	36.2	36.2	36.2	36.3	36.2	36.2	36.2
	Fattening cattle	Japanese cattle (M): 1 yr and over	73.2	73.4	73.2	72.8	72.7	72.8	68.5	68.5	68.5	68.7	68.5	68.5	68.5
		Japanese cattle (M): under 1 yr, over 6 mth	61.1	61.3	61.1	61.2	61.2	61.4	64.5	64.5	64.5	64.7	64.5	64.5	64.5
		Japanese cattle (M): 5 and 6 mth	39.6	39.7	39.6	39.9	40.0	40.2	39.8	39.8	39.8	39.9	39.8	39.8	39.8
		Japanese cattle (F): 1 yr and over	51.8	51.9	58.1	54.2	53.5	52.8	51.9	51.9	51.9	52.0	51.9	51.9	51.9
		Japanese cattle (F): under 1 yr, over 6 mth	44.3	44.5	55.3	51.2	50.4	49.7	48.7	48.7	48.7	48.8	48.7	48.7	48.7
		Japanese cattle (F): 5 and 6 mth	31.0	31.0	37.4	34.6	34.0	33.5	32.9	32.9	32.9	33.0	32.9	32.9	32.9
		Dairy breed: over 6 mth	75.6	75.8	75.6	75.6	75.6	75.8	75.6	75.6	75.6	75.8	75.6	75.6	75.6
		Dairy breed: 5 and 6 mth	48.0	48.1	48.0	48.0	48.0	48.1	48.0	48.0	48.0	48.1	48.0	48.0	48.0

- ***Activity Data***

For activity data of this source, the herd size for each type of livestock at 1 February in each year, recorded by the MAFF in its *Livestock Statistics* is used.

Table 5-10 Livestock population for cattle (single year) [1000 head]

Animal Type			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle		Lactating	1,082	1,035	971	900	871	862	848	830	805	813	798	773	750
		Non-lactating	332	299	249	231	221	213	207	200	195	200	194	185	184
		Heifer: under 2 yr, over 6 mth	491	445	379	379	375	344	334	341	351	328	323	328	328
		Heifer: 5 and 6 mth	55	49	42	42	42	38	37	38	39	36	36	36	36
		Heifer: under 5 mth	109	99	84	84	83	76	74	76	78	73	72	73	73
Dairy cattle total			**2,068**	**1,927**	**1,725**	**1,636**	**1,592**	**1,533**	**1,500**	**1,484**	**1,467**	**1,449**	**1,423**	**1,395**	**1,371**
Non-dairy cattle	Breeding	1 yr and over	679	646	612	594	608	634	651	651	636	614	593	568	553
		Under 1 yr, over 6 mth	17	13	12	14	14	17	16	17	16	14	13	14	13
		5 and 6 mth	6	4	4	5	5	6	5	6	5	5	4	5	4
		Under 5 mth	12	9	8	9	9	11	10	11	11	9	9	9	9
	Fattening cattle	Japanese cattle (M): 1 yr and over	368	412	385	374	392	407	414	425	409	405	396	381	368
		Japanese cattle (M): under 1 yr, over 6 mth	125	133	114	119	118	123	130	132	127	123	116	115	112
		Japanese cattle (M): 5 and 6 mth	42	44	38	40	39	41	43	44	42	41	39	38	37
		Japanese cattle (M): under 5 mth	83	89	76	80	79	82	87	88	85	82	77	77	75
		Japanese cattle (F): 1 yr and over	197	265	246	290	291	309	322	339	336	343	337	328	313
		Japanese cattle (F): under 1 yr, over 6 mth	102	105	93	89	93	96	105	106	101	98	93	91	89
		Japanese cattle (F): 5 and 6 mth	34	35	31	30	31	32	35	35	34	33	31	30	30
		Japanese cattle (F): under 5 mth	68	70	62	59	62	64	70	70	67	65	62	60	59
		Dairy breed: over 6 mth	805	808	845	789	798	800	775	726	671	669	655	639	621
		Dairy breed: 5 and 6 mth	89	90	94	88	89	89	86	81	75	74	73	71	69
		Dairy breed: under 5 mth	179	180	188	175	177	178	172	161	149	149	146	142	138
Non-dairy cattle total			**2,805**	**2,901**	**2,806**	**2,755**	**2,806**	**2,890**	**2,923**	**2,892**	**2,763**	**2,723**	**2,642**	**2,567**	**2,489**

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties for emission factors were calculated by finding the 95% confidence interval in accordance with the equation indicated in the section Emission Factors (Dairy cattle: -26% to +32%, non-dairy cattle: -40% to +49%). Populations of cattle (activity data) are decided by survey of total population in the *Livestock Statistics*, but standard error for cattle is not described. Therefore, the uncertainties for activity data were substituted by 1% of swine in the *Livestock Statistics*. As a result, the uncertainties of the emissions were determined to be -26% to +32% for dairy cattle and -40% to +49% for non-dairy cattle.

- ***Time-series Consistency***

Emission factors were calculated consistently from FY1990 onward by the method mentioned in the

section on Emission Factors. Activity data were used consistently from FY1990 onward from the data in the *Livestock Statistics*.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

Comparison between results of Japan's estimation method and IPCC Tier 2 method was conducted. For Tier2 method, equations indicated in the *2006 IPCC Guidelines* (Equation 10.3~10.16) are used, and estimation is conducted by classification described in Table 5-2 above. If data is available, Japan's data are used (e.g. values of Table 5-3 to 5-7 above and values of DE calculated from data described in the *Japan Feed Standards* (Reference 20). If not available, default data described in the *2006 IPCC Guidelines* are used (e.g. Ym, Cfi and Cpregnancy).

As a result, for both dairy cattle and non-dairy cattle, considering the error of CH_4 conversion factor (Ym = 6.5%±1.0%), the emissions based on Japan's method were in the range calculated by IPCC Tier 2 method. Therefore, it is considered that there were no significant differences between emissions of Japan's method and IPCC Tier 2 method.

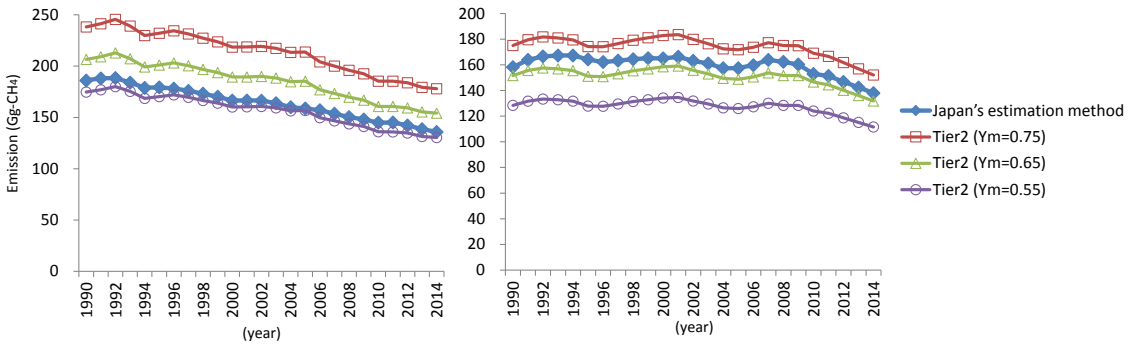

Figure 5-2Comparison between results of Japan's estimation method and IPCC Tier 2 method
(Left: Dairy cattle, Right: Non-dairy cattle)

e) Category-specific Recalculations

No recalculation.

f) Category-specific Planned Improvements

It is planned to discuss the development of the estimation method, which reflects the emissions reduction with technologies that suppress methane fermentation by controlling the rumen fermentation (such as by the addition of fatty acid calcium to feed) and by improving the feed efficiency with the total mixed ration (TMR) feeding.

5.2.2. Buffalo, Sheep, Goats, Horses & Swine (3.A.2., 3.A.3., 3.A.4.)

a) Category Description

This section provides the estimation methods for CH_4 emissions from enteric fermentation in buffalo,

sheep, goats, horses and swine.

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions were calculated using the Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines*.

$$E = EF \times A$$

E : CH_4 emissions from enteric fermentation for each livestock [kg-CH_4]
EF : CH_4 Emission factor for enteric fermentation of each livestock [kg-CH_4 /head]
A : Livestock population of each livestock [head]

- ***Emission Factors***

The emission factors for swine have been established on the basis of results of research conducted in Japan. The emission factor for sheep, goats, horses and buffalo are the default values given in the *2006 IPCC Guidelines*.

Table 5-11 Emission factors for CH_4 associated with enteric fermentation in swine, sheep, goats, horses and buffalo

Animal type	CH_4 emission factor [kg/year/head]	Reference
Swine	1.4	Established on the basis of results of Mamoru Saito, *Methane emissions from fattening swine and expectant swine* (1988) (Reference 23)
Sheep	8	2006*IPCC Guidelines*
Goats	5	
Horses	18.0	
Buffalo	55.0	

- ***Activity Data***

For activity data of sheep and goats, livestock population data given in the *Statistical Document of Livestock Breeding* offered by the Japan Livestock Industry Association before FY2009 and the *"Status Report regarding Health Management for Livestock Feeding"* by the MAFF from FY2013 onward are used. For swine, livestock population at February 1st in each year recorded in the *Livestock Statistics* by the MAFF are used. For horses, livestock population given in the *Statistical Document of Horse* offered by the MAFF before 2009 and the *"Status Report regarding Health Management for Livestock Feeding"* by the MAFF from FY2013 onward are used. For buffalo, livestock population given in the *Statistics on Livestock in Okinawa Prefecture* are used.

Table 5-12 Livestock population for buffalo, sheep, goats, swine, and horses [1000 heads]

Type of animal	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Sheep	21	14	12	9	10	10	12	14	15	16	16	17	17
Goats	26	19	22	16	15	15	14	14	15	17	19	20	20
Swine	11,335	9,900	9,788	9,620	9,759	9,745	9,899	9,834	9,768	9,735	9,685	9,537	9,537
Horses	116	118	105	87	84	83	81	81	80	78	76	74	74
Buffalo	0.21	0.12	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.10	0.11

*For swine, data in 2004 and 2009 were interpolated. Data in 2014 was substituted by the value of 2013.
For sheep, goats and horses, data from 2010 and 2012 were interpolated. Data in 2014 was substituted by the value of 2013.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

An uncertainty assessment was conducted by each livestock category. The uncertainties for emission factors for swine were decided by the Committee of GHG Emissions Estimation Methods. The uncertainties for emission factors of livestock other than swine were applied 50% of default data given in the *2006 IPCC Guidelines*. As the uncertainty for activity data of swine, 1% of standard error for swine given in the *Livestock Statistic* was applied. For activity data of livestock other than swine, uncertainty was substituted by the value of broiler (9%) described in the *Livestock Statistics*. As a result, the uncertainties of the emissions were determined to be -72% to +157% for swine and 51% for buffalo, sheep and goats and horses.

- ***Time-series Consistency***

For emission factors, same values were used consistently from FY1990 to FY2014. For activity data, the data given in the *Statistical Document of Livestock Breeding*, the *Livestock Statistics*, the *Statistical Document of Horse*, the *Livestock Statistics of Okinawa*, and the *Status Report regarding Health Management for Livestock Feeding* are used, and consistent estimation method by each livestock are used since FY1990.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since activity data (livestock population) were updated for sheep, goats and horses, emissions from FY2010 to FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no improvement plans.

5.2.3. Other Livestock (3.A.4.-)

It is conceivable that CH_4 is emitted from enteric fermentation in poultry, but the Japanese literature offers no data on emission factors, and neither the *Revised 2006 IPCC Guidelines* offer default emission factors. Therefore, this category has been reported as “NE”. Deer, alpaca, which are not reported above, but default emission factors are reported in the *2006 IPCC Guidelines*, are farmed as livestock in Japan. However, their population size is small, and the emissions from each of them are lower than 3000t-CO_2 equivalent, which is the threshold to estimate in this GHG inventory decided by the Committee for GHG Emissions Estimation Methods. Therefore, it was reported as "NE." as considered insignificant (See Annex 5).

5.3. Manure Management (3.B.)

In livestock manure management process, CH_4 is generated by decomposing organic content in livestock manure with CH_4 fermentation. In addition, CH_4 generated by enteric fermentation

dissolved in manure is released by aeration or agitation. In manure management, N_2O is produced mainly by microorganism via nitrification and denitrification processes.

Table 5-13 CH_4 and N_2O emissions from livestock manure management

Gas	Livestock species	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	3.B.1.- Dairy cattle	kt-CH_4	116.0	109.1	99.2	94.8	92.5	90.8	89.3	88.4	86.6	86.8	85.0	82.7	80.9
	3.B.1.- Non-dairy cattle	kt-CH_4	4.3	4.5	4.5	5.2	5.5	5.9	6.1	6.2	6.0	5.9	5.7	5.5	5.4
	3.B.2. Sheep	kt-CH_4	0.006	0.004	0.003	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005
	3.B.3. Swine	kt-CH_4	11.1	9.7	9.1	6.6	6.3	5.9	5.5	5.1	5.0	5.0	5.0	4.9	4.9
	3.B.4.- Buffalo	kt-CH_4	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	3.B.4.- Goats	kt-CH_4	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004
	3.B.4.- Horses	kt-CH_4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	3.B.4.- Poultry	kt-CH_4	2.3	2.2	2.1	2.4	2.6	2.6	2.7	2.8	2.9	3.0	3.0	3.1	3.1
	3.B.4.- Rabbit	kt-CH_4	0.001	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	3.B.4.- Mink	kt-CH_4	0.1053	0.0073	0.0038	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
	Total	kt-CH_4	134.1	125.8	115.2	109.3	107.0	105.4	103.9	102.8	100.7	100.9	98.9	96.4	94.4
		kt-CO_2eq	3,353	3,146	2,879	2,733	2,676	2,634	2,596	2,569	2,518	2,521	2,472	2,410	2,361
N_2O	3.B.1.- Dairy cattle	kt-N_2O	2.5	2.3	2.2	2.5	2.6	2.6	2.7	2.7	2.7	2.7	2.6	2.6	2.5
	3.B.1.- Non-dairy cattle	kt-N_2O	2.8	2.9	2.9	3.0	3.1	3.3	3.3	3.4	3.2	3.2	3.1	3.0	2.9
	3.B.2. Sheep	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	3.B.3. Swine	kt-N_2O	3.0	2.6	2.7	3.4	3.6	3.8	4.0	4.1	4.1	4.1	4.0	4.0	4.0
	3.B.4.- Buffalo	kt-N_2O	0.00012	0.00007	0.00006	0.00005	0.00005	0.00005	0.00004	0.00005	0.00004	0.00005	0.00005	0.00005	0.00006
	3.B.4.- Goats	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	3.B.4.- Horses	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	3.B.4.- Poultry	kt-N_2O	1.4	1.4	1.3	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8
	3.B.4.- Rabbit	kt-N_2O	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
	3.B.4.- Mink	kt-N_2O	0.0223	0.0016	0.0008	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	3.B.5. Indirect emissions	kt-N_2O	4.6	4.3	4.1	3.9	4.0	3.9	3.9	3.9	3.9	4.0	4.0	4.0	3.9
	Total	kt-N_2O	14.3	13.5	13.2	14.4	14.8	15.2	15.5	15.8	15.6	15.6	15.4	15.2	15.1
		kt-CO_2eq	4,249	4,038	3,936	4,278	4,422	4,524	4,625	4,710	4,650	4,654	4,597	4,543	4,494
Total of all gases		kt-CO_2eq	7,602	7,183	6,815	7,011	7,098	7,158	7,222	7,279	7,168	7,175	7,069	6,954	6,854

CH_4 and N_2O emissions from manure management in FY2014 are 2,361 kt-CO_2 eq. and 4,494 kt-CO_2 eq., comprising 0.2% and 0.3% of total emissions (excluding LULUCF), respectively. The value represents a reduction by 29.6% for CH_4 and an increase by 5.8% for N_2O from FY1990. Main driver of the CH_4 emission decrease from FY1990 is a reduction of dairy cattle population, and of the N_2O emission increase from FY1990 is a change of manure management system with higher emission factor.

5.3.1. Cattle, Swine and Poultry (Hen and Broiler) (3.B.1., 3.B.3., 3.B.4.)

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions for manure management from cattle (dairy cattle and non-dairy cattle), swine and poultry (hen and broilers). For grazing animal, CH_4 emissions were reported in this category and N_2O emissions were reported in "3.D.a.3. Urine and dung deposited by grazing animals".

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions associated with the manure management were calculated by multiplying the amount of organic matter contained in manure from each type of livestock by the emission factor for each type of treatment method.

$$E_{CH4} = \sum \left(EF_{CH4-n} \times A_{CH4-n} \right)$$

E_{CH4-n} : CH_4 emissions associated with the management of manure excreted by cattle, swine and poultry [g-CH_4]
EF_{CH4-n} : Emission factor for treatment method *n* [g-CH_4/g-organic matter];
A_{CH4-n} : Amount of organic matter contained in manure treated by method *n* [g-organic matter].

N_2O emissions were calculated by multiplying the amount of nitrogen contained in manure of each type of animal by the emission factor for each type of treatment method.

$$E_{N2O} = \sum \left(EF_{N2O-n} \times A_{N2O-n} \right) \times 44/28$$

E_{N2O} : N_2O emission associated with management of manure excreted by cattle, swine and poultry [g-N_2O]
EF_{N2O-n} : Emission factor for treatment method *n* [g-N_2O-N/g-N];
A_{N2O-n} : Amount of nitrogen contained in manure treated by method *n* [g-N]

- ***Emission Factors***

Emission factors for CH_4 and N_2O associated with Animal Waste Management System (hereafter, AWMS) have been established for each treating method of for each type of livestock, on the basis of the results of research by actual measurements carried out in Japan after reviewing its validity in accordance with the decision tree shown in Figure 5-3.

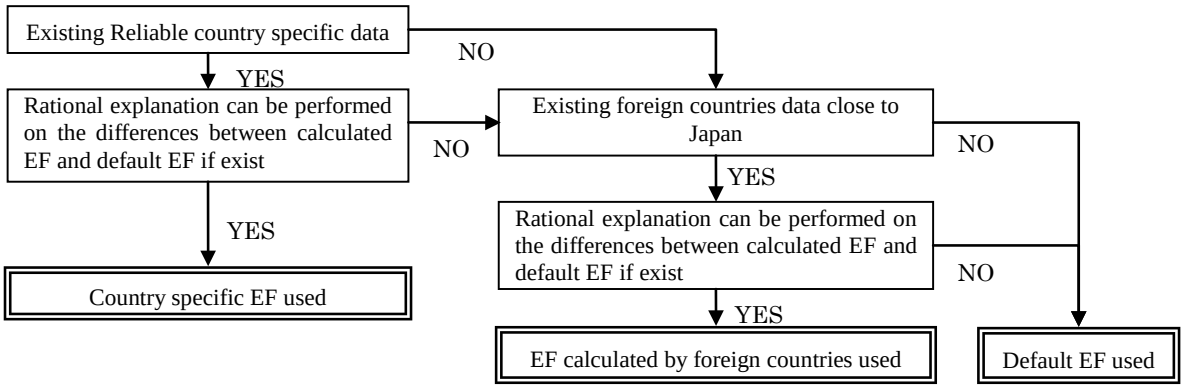

Figure 5-3 Decision tree for determination of EF

Emission factors for CH_4 indicated by "D (default value)" in Table 5-16 and Table 5-17 were calculated by following equation with Bo (maximum methane producing capacity) (Dairy cattle: 0.13, Non-dairy cattle: 0.10, Swine: 0.29) and MCF (methane conversion factor) in "Asia" indicated in the *2006 IPCC Guidelines*. Since MCF for pit storage and composting are described by each temperature in the *2006 IPCC Guidelines*, MCF values are calculated with weighted average by regional livestock population and regional MCF decided by the average temperature in each region. Average temperature by region used for development of MCF values is shown in the following Table 5-14. These temperatures were established by the use of average temperatures in each municipality where livestock are mainly housed.

For country-specific emission factors, MCF values are not established because emission factors are estimated directly from results of actual measurement data.

$$EF_{CH4-n} = Bo \times 0.67 \times MCF$$

EF_{CH4-n} : Emission factor for treatment method *n* [g-CH_4/g-organic matter]
Bo : Maximum methane producing capacity [m^3-CH_4/kg-organic matter]

0.67 : Conversion factor from volume to weight [kg-CH_4/m^3-CH_4]

MCF : Methane conversion factor [%]

Table 5-14 Average temperature by region used for development of MCF values [°C]

	Dairy cattle	Non-dairy cattle	Swine
Hokkaido	5.3	6.2	7.4
Tohoku	8.5	11.0	10.1
Kanto	11.9	12.1	14.4
Hokuriku	14.0	14.0	12.7
Tokai	16.0	14.3	15.0
Kinki	15.9	16.0	13.5
Chugoku	14.6	15.0	14.4
Shikoku	16.3	16.1	15.5
Kyusyu and Okinawa	15.8	16.5	16.3

Table 5-15 MCFs (methane conversion factor) used for calculation of default emission factors

Treating method	MCF	System in the *2006 IPCC Guidelines*
Pit storage (non-dairy cattle)	24%	Liquid/ Slurry- Without natural Crust (calculated by weighted average)
Pit storage (swine)	25%	Liquid/ Slurry- Without natural Crust (calculated by weighted average)
Composting (dairy cattle)	0.6%	Composting - In-vessel (calculated by weighted average)
Composting (non-dairy cattle)	0.8%	Composting - In-vessel (calculated by weighted average)
Purification (dairy cattle, non-dairy cattle)	0%	Aerobic treatment

* For other treating method than the above, MCF values are not established because country-specific emission factors are used.

Reference: *2006 IPCC Guidelines*, Table10.17 (Reference 1)

For “Piling”, the most major manure management practice in Japan, Osada et al. (2005, Reference 32) measured actual CH_4 and N_2O emissions by using chamber system covering compost heap, and Japan’s emission factors for dairy cattle, non- dairy cattle and swine were set from these data.

For “Pasture, range and paddock” of dairy cattle and non-dairy cattle, emission factors were established by actual measurement data of collected manure set in chamber in grazing area. Detail method is described in the paper by Mori et al. (2015, Reference 65).

For emission factors of Composting (feses) for hen and broiler, emission factor for swine is applied by expert judgment.

For CH_4 emission factors of “Pit storage” and “Methane fermentation” for dairy cattle, regional emission factors of 9 regions in Japan were established by using air temperature as a parameter, and based on actual measurement data on pit storage system and methane fermentation system by using measurement technique such as floating chamber method (MAFF survey (Reference 52)). Therefore, integrated emission factors for all Japan, which are weighted averages of the regional emission factors with dairy cattle population in each region (described in the *Livestock Statistics*), are used (see Table 5-18). Emission factors in latest year are lower than 1990 because ratio of livestock population in Hokkaido region, where temperature is low and emission factor is low, has gradually increased (1990: 42% and 2012: 57%).

Moisture for dairy cattle feces is high, and they easily make anaerobic condition. It is considered to be the reason for high CH_4 emission factor of piling.

Table 5-16 CH_4 Emission factors for each method of treating manure from cattle, swine, hen & broiler [g-CH_4/g-organic matter]

Treating method	Dairy cattle		Non-dairy cattle		Swine		Hen, broiler	
Pit storage	Table 5-18	J[10]	1.6 %	D[1]	4.9 %	D[1]	–	
Sun drying	0.20 %	J[3]	0.20 %	J[3]	0.20 %	J[3]	0.14 %	J[11]
Thermal drying	0 %							Z[4]
Composting (feces)	0.052 %	D[1]	0.054 %	D[1]	0.080 %	J[8]	0.080%	Sw
Piling	3.80 %	J[5]	0.13 %	J[5]	0.16 %	J[5]	Hen: 0.13 %, Broiler 0.02 %	J[13]
Incineration	0.4 %							O[4,2]
Composting (urine)	0.052 %	D[1]	0.054 %	D[1]	0.097 %	D[1]	–	
Composting (feces and urine mixed)					0.080 %	J[8]		
Purification	0%	D[1]	0%	D[1]	0.91 %	J[12]		
Methane fermentation (feces)	3.80%	Pl	0.13%	Pl	0.16%	Pl	Hen: 0.13 %, Broiler 0.02 %	Pl
Methane fermentation (feces and urine mixed)	Table 5-18	J[9]	3.0%	PS	8.7%	PS	–	
Pasture, range and paddock	0.076%			J[10]	–		0.14%	SD
Other (feces)	3.80%	M	0.4%	M	0.4%	M	0.4%	M
Other (feces and urine mixed)	3.90%	M	3.0%	M	8.7%	M	–	

* See notation and sources of Table 5-17 below.

Table 5-17 N_2O Emission factors for each method of treating manure from cattle, swine hen & broiler [g-N_2O-N/g-N]

treating method	Dairy cattle		Non-dairy cattle		Swine		Hen, Broiler	
Pit storage	0.02%	J[9]	0 %			D[1]		
Sun drying	2.0 %					D[1]	0.33%	J[11]
Thermal drying	2.0 %							D[1]
Composting (feces)	0.25 %			J[6]	0.16 %	J[8]	0.16 %	Sw
Piling	2.40 %	J[5]	1.60 %	J[5]	2.50 %	J[5]	Hen: 0.54%, Broiler 0.08%	J[13]
Incineration	0.1 %							O[4]
Composting (urine)	1.0%					D[1]	–	
Composting (feces and urine mixed)	1.0%	D[1]	0.25%	J[6]	0.16%	J[8]		
Purification	5.0 %			J[7]	2.87%	J[12]		
Methane fermentation (feces)	2.40 %	Pl	1.60 %	Pl	2.50 %	Pl	Hen: 0.54%, Broiler 0.08%	Pl
Methane fermentation (feces and urine mixed)	0.15%	J[9]	0.1 %			PS	–	
Pasture, range and paddock	0.684%			J[10]	–		0.33%	SD
Other (feces)	2.4%	M	2.0%	M	2.5%	M	2.0%	M
Other (feces and urine mixed)	5.0%	M	5.0%	M	2.87%	M	–	

D: Default value of the *2006 IPCC Guidelines*
J: Established by data of Japan
O: Established by data of other countries
Z: Emission can not occur because of mechanism
Pl: Application of the value of "Piling"
PS: Application of the value of "Pit storage"
SD: Application for the value of "Sun drying"
Sw: Application for the value of "Swine"
M: Application of the maximum values of the treating methods for "feces" or "feces and urine mixed"
* Manure excreted by hen and broiler was categorized as feces since it contains a very small amount of urine.

Sources for Table 5-16 and Table 5-17
1: *2006 IPCC Guidelines* (Reference 1)
2: IPCC(1995): *IPCC 1995 Report* (Reference 2)
3: Makoto Ishibashi et al., *"Development of technology of reducing GHG on the livestock industry(second report)"* (2003) (Reference 28)
4: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*, (2002) (Reference 17)
5: Takashi Osada et al., *Greenhouse gas generation from livestock waste composting* (2005) (Reference 32)
6: Takashi Osada et al., *Determination of nitrous oxide, methane, and ammonia emissions from a swine waste composting process* (2000) (Reference 30)
7: Takashi Osada, *Nitrous Oxide Emission from Purification of Liquid Portion of Swine Wastewater* (2003) (Reference 31)
8: *Project Report of Survey on Prevention of Global Warming in the Agriculture, Forest and Fisheries Sector within the Environment and Biomass Comprehensive Strategy Promotion Project in FY2008 (Nationwide Survey)* (Reference 41)
9: MAFF, *Project on Survey and Investigation for Elaboration of GHG Emissions from Agriculture, Forest and Fisheries Sector, within the Project on Development for Method of Promotion for Countermeasures of Global Environment in the Agriculture, Forest and Fisheries Sector in FY2011* (2012) (Reference 52)
10: Akinori Mori and Masayuki Hojito, *"Methane and nitrous oxide emissions due to excreta returns from graizing cattle in Nasu, Japan"*, Grassland Science (2015) (Reference 65)
11: Izumi Tsuchiya, et al., *Measurement of greenhouse gas emissions in drying treatment facility for poultry manure* (2013) (Reference 54)
12: MAFF, *Project on Survey and Investigation for Elaboration of GHG Emissions from Agriculture, Forest and Fisheries Sector, within the Project on Development for Method of Promotion for Countermeasures of Global Environment in the Agriculture, Forest and Fisheries Sector in FY2012* (2013) (Reference 55)
13: MAFF, *Project on Survey and Investigation for Elaboration of GHG Emissions from Agriculture, Forest and Fisheries Sector, within the Project on Development for Method of Promotion for Countermeasures of Global Environment in the Agriculture, Forest and Fisheries Sector in FY2013* (2014) (Reference 56)

Table 5-18 CH_4 Emission factors for "Pit storage" and "Methane fermentation" for dairy cattle
[g-CH_4/g-organic matter]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Pit storage	2.47%	2.44%	2.42%	2.40%	2.40%	2.39%	2.39%	2.38%	2.37%	2.37%	2.37%	2.37%	2.37%
Methane fermentation	3.22%	3.17%	3.14%	3.11%	3.11%	3.10%	3.08%	3.07%	3.06%	3.06%	3.06%	3.06%	3.05%

Note: These figures are weighted averages of regional emission factors by MAFF survey (Reference 52, No.10 above) with dairy cattle population in each region.

- ***Activity Data***

The values used for the activity data are estimates of the amount of organic matter and the amount of nitrogen excreted annually by various types of livestock, respectively.

$$A_{CH4\text{-}n} = P \times Ex \times Day \times Org \times Mix_n \times MS_n /1000$$

$$A_{N2O\text{-}n} = P \times Nex \times Day \times Mix_n \times MS_n /1000$$

$A_{CH4\text{-}n}$	: Amount of organic matter excreted [kt]
$A_{N2O\text{-}n}$	: Amount of nitrogen excreted by each type of livestock [kt]
P	: Livestock population [1000 head]
Ex	: Amount of feces and urine excreted per head per day [kg/head/day]
Org	: Organic matter content in feces and urine [%]
Nex	: Nitrogen content amount of feces and urine excreted per head per day [kg-N/head/day]
Day	: Days in a year [day]
Mix_n	: Proportion of feces and urine separated [%]
MS_n	: Share of each treating method [%]

Total annual amount of organic matter by livestock was calculated by multiplying the population of each type of animal by the amount of manure per head by the proportion of organic matter in feces or urine. Total nitrogen amount was calculated by multiplying the population of each type of animal by the nitrogen content amount of feces or urine excreted per head. The amount of organic matter and nitrogen amount was allocated to each category of manure management by multiplying the total

amount by the percentage of manure treated separately and the percentage per treatment method. For "Percentage of manure management by type of animal" and "Proportion of separated and mixed treatment of manure, by type of livestock", there are two results of surveys in 1997 and 2009. The 1997 survey is data before enforcement of the "*Act on the Appropriate Treatment and Promotion of Utilization of Livestock Manure*" which has been in force since 1999 and prohibits inappropriate manure management and induced changes of percentage of manure management. Therefore, the 1997 survey results were applied before 1999 and the 2009 survey results were applied after 2009. For 2000 to 2008, interpolation was used (Table 5-22 and Table 5-23).

For livestock population, same references indicated in '4.A. Enteric Fermentation' for dairy cattle non-dairy cattle and swine are used. Livestock population for hen and broiler described in the *"Livestock Statistics"* and *"Statistics on Livestock Products Marketing"* are used (see the following Table 5-19).

Table 5-19 Livestock population for hen and broiler [1000 heads]

Type of livestock	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Hen	188,786	190,634	186,202	180,697	186,583	184,773	180,994	179,770	178,546	177,607	174,784	174,806	174,806
Broiler	142,740	118,123	106,311	103,687	105,287	102,987	107,141	113,262	119,383	125,503	131,624	135,747	135,747

* Data of non-surveyed year (in 2009 to 2011 for broiler, and in 2004 and 2009 for hen) were interpolated. Data in 2014 for hen and broiler was substituted by the value of 2013.
Source: MAFF, *Livestock Statistics*, *Statistics on Livestock Products Marketing*

Table 5-20 Amount of feces and urine excreted (Ex) and nitrogen content amount by type of livestock(Nex)

Type of livestock		Amount of feces and urine excreted [kg/head/day]		Nitrogen content amount in feces and urine excreted [g-N/head/day]	
		feces	urine	Feces	urine
Dairy cattle	Lactating	45.5	13.4	152.8	152.7
	Non-lactating and inexperienced birthing	29.7	6.1	38.5	57.8
	Heifer: under two yr.	17.9	6.7	85.3	73.3
Non-dairy cattle	Under two yr.	17.8	6.5	67.8	62.0
	Over two yr.	20.0	6.7	62.7	83.3
	Dairy breed	18.0	7.2	64.7	76.4
Swine	Growing-finishing	2.1	3.8	8.3	25.9
	Breeding	3.3	7.0	11.0	40.0
Hen	Poult	0.059	-	1.54	-
	Adult	0.136	-	3.28	-
Broiler		0.130	-	2.62	-

Source: M, Tsuiki et al., *A Computer Program for Estimating the Amount of Livestock Wastes*. (Reference 38)

Table 5-21 Organic matter content in feces and urine, by type of livestock (wet base) (Org)

Type of livestock	Organic matter content	
	Feces	Urine
Dairy cattle	16%	0.5%
Non-dairy cattle	18%	0.5%
Swine	20%	0.5%
Hen	15%	—
Broiler	15%	—

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 17)

Table 5-22 Percentage of manure management by type of animal (dairy cattle, non-dairy cattle and swine) (MS_n)

State of Manure (Separated or Mixed)		Treating method	Dairy cattle			Non-dairy cattle			Swine		
			~1999	2000~2008	2009~	~1999	2000~2008	2009~	~1999	2000~2008	2009~
Separated	Feces	Sun drying	2.8%	Interpolation	2.0%	1.5%	Interpolation	0.9%	7.0%	Interpolation	0.7%
		Thermal drying	0%	—	0%	0%	—	0%	0.7%	Interpolation	0.1%
		Composting	9.0%	Interpolation	6.6%	11.0%	Interpolation	8.1%	62.0%	Interpolation	48.2%
		Piling	88.0%	Interpolation	90.1%	87.0%	Interpolation	89.8%	29.6%	Interpolation	49.3%
		Incineration	0.2%	Interpolation	0%	0.5%	Interpolation	—	0.7%	Interpolation	0.6%
		Methane fermentation	—	—	—	—	—	—	—	Interpolation	0.1%
		public sewage	—	—	0%	—	—	—	—	—	—
		Pasturage	—	—	0%	—	—	—	—	—	—
		Other	—	Interpolation	1.3%	—	Interpolation	1.2%	—	Interpolation	1.0%
	Urine	Sun drying	—	—	0%	—	—	0%	—	—	0%
		Composting (urine)	1.5%	Interpolation	1.7%	9.0%	Interpolation	1.2%	10.0%	Interpolation	5.4%
		Purification	2.5%	Interpolation	5.1%	2.0%	Interpolation	4.4%	45.0%	Interpolation	76.3%
		Pit storage	96.0%	Interpolation	89.6%	89.0%	Interpolation	91.5%	45.0%	Interpolation	15.3%
		Methane fermentation	—	Interpolation	1.9%	—	—	0%	—	Interpolation	0.5%
		Public sewage	—	Interpolation	0.8%	—	Interpolation	0.6%	—	Interpolation	0.4%
		Other	—	Interpolation	0.9%	—	Interpolation	2.4%	—	Interpolation	2.1%
Mixed		Sun drying	4.4%*	Interpolation	1.1%	3.4%*	Interpolation	0.7%	6.0%	Interpolation	0.2%
		Thermal drying	0%	—	0%	0%	—	0%	0%	—	0%
		Composting (urine)	18.7%*	Interpolation	22.9%	21.8%*	Interpolation	10.8%	29.0%	Interpolation	21.3%
		Piling	13.1%*	Interpolation	50.9%	73.2%*	Interpolation	85.6%	20.0%	Interpolation	51.3%
		Purification	0.3%*	Interpolation	0.2%	0%	—	0%	22.0%	Interpolation	18.5%
		Pit storage	57.1%*	Interpolation	15.4%	0.6%*	Interpolation	0.1%	23.0%	Interpolation	4.0%
		Incineration	—	Interpolation	0.1%	—	—	0%	—	—	0%
		Methane fermentation	—	Interpolation	1.7%	—	—	0%	—	Interpolation	2.0%
		Public sewage	—	Interpolation	0.1%	—	—	0%	—	Interpolation	0.7%
		Pasturage	6.5%*	Interpolation	6.5%	1.1%*	Interpolation	1.1%	—	—	0%
		Other	—	Interpolation	1.2%	—	Interpolation	1.6%	—	Interpolation	1.9%

Source: ~1999: Japan Livestock Technology Association, *GHGs emissions control in livestock Part4*. (1999) (Reference 18)
2009~: MAFF, *Survey of current status for livestock manure management system* (2009) (Reference 51)
*: For dairy cattle and non-dairy cattle, percentage of "Pasturage" are not indicated in Japan Livestock Association data (Reference 18). Therefore, the percentages of "Pasturage" indicated in Reference 51 are applied to all the years consistently. In addition, each percentage of the mixed management of dairy cattle and non-dairy cattle is adjusted so that the sum of the percentages can be 100%.

Table 5-23 Percentage of manure management by type of animal (hen and broiler) (MS_n)

State of Manure (Separated or Mixed)		Treating method	Hen			Broiler		
			~1999	2000~2008	2009~	~1999	2000~2008	2009~
Separated	Feces	Sun drying	30.0%	Interpolation	8.2%	15.0%	Interpolation	2.5%
		Thermal drying	3.0%	Interpolation	2.2%	0%	Interpolation	1.1%
		Composting	42.0%	Interpolation	49.6%	5.1%	Interpolation	19.3%
		Piling	23.0%	Interpolation	36.8%	66.9%	Interpolation	36.7%
		Incineration	2.0%	Interpolation	1.6%	13.0%	Interpolation	30.5%
		Methane fermentation	—	—	—	—	Interpolation	0.1%
		public sewage	—	—	—	—	—	—
		Pasturage	—	—	0%	—	Interpolation	0.1%
		Other	—	Interpolation	1.6%	—	Interpolation	9.9%

Source: See Table 5-22 above

Table 5-24 Proportion of separated and mixed treatment of manure, by type of livestock (Mix_n)

Type of livestock	Separated			Mixed		
	~1999	2000~2008	2009~	~1999	2000~2008	2009~
Dairy cattle	60%	Interpolation	45.5%	40%	Interpolation	54.5%
Non-dairy cattle	7%	Interpolation	4.8%	93%	Interpolation	95.2%
Swine	70%	Interpolation	73.9%	30%	Interpolation	26.1%
Hen	100%	Interpolation	100%	—	—	—
Broiler	100%	Interpolation	100%	—	—	—

Source: Until 1999: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 17),
From 2009 onward: MAFF, *Survey of current status for livestock manure management system* (2009) (Reference 51)

- ***Reporting in Common Reporting Format (CRF)***

In the CRF, with regard to nitrogen amount of manure (MMS) from this category, it is required to report emissions by AWMS ("Anaerobic Lagoons", "Liquid Systems", "Daily Spread", "Solid Storage and Dry Lot", "Pasture, Range and Paddock", "Composting", "Digesers", "Burned for Fuel or as Waste", and "Other").

For cattle, swine, and poultry, Japan's country-specific manure management categories and the implementation rates of the management categories have been established for each type of animal. For details, see Table 5-25 below.

Table 5-25 Correspondence between the Japanese and CRF manure management categories

Sub-categories in Japan			Classification in CRF	Description of treatment
Manure treatment		Manure management category		
Separate treatment	Feces	Sun drying	Solid storage and dry lot	Dried under sunlight to facilitate handling (for storage and odor prevention).
		Thermal drying	Other system	Dried by heat to facilitate handling.
		Composting	Composting	Fermented for several days to several weeks with forced aeration and agitation in lidded or closed tanks.
		Piling	Composting	Piling system is a method of composting. Piled about 1.5-2m height on compost bed or in shed to ferment for several months with occasional turning.
		Incineration	Burned for fuel or as waste	For amount reduction or disposal, and use as an energy source (e.g. chicken manure boiler).
		Methane fermentation	Digesters	Slurry livestock manure is fermented under anaerobic conditions. Generated methane gas is used as an energy source.
		Public sewage	-	Released into public sewage without purification or aeration management. Emissions are included in the Waste sector.
		Pasture, range and paddock	Pasture, range and paddock	Livestock are fed on a land with vegetation to eat. N_2O Emissions are reported in the 'Urine and dung deposited by grazing animals (3.D.a.3.)'
		Other	Other system	Treated with the method not mentioned above.
	Urine	Liquid composting	Composting	Treated in an aeration storage tank.
		Purification	Aerobic treatment	Separate pollutants using aerobic microbes, such as activated sludge.
		Pit storage	Liquid systems	Stored in a storage tank.
		Methane fermentation	Digesters	Same as above (Methane fermentation)
		Public sewage	-	Same as above (Public sewage)
		Other	Other system	Treated with the method not mentioned above.
Mixed treatment		Sun drying	Solid storage and dry lot	Dried under sunlight to facilitate handling.
		Thermal drying	Other system	Same as above, Thermal drying.
		Liquid composting	Composting	Treated in an aeration storage tank.
		Piling	Composting	Same as above, Piling.
		Purification	Aerobic treatment	Same as above, Purification.
		Pit storage	Liquid systems	Stored in a storage tank (e.g. slurry storage).
		Methane fermentation	Digesters	Same as above (Methane fermentation).
		Public sewage	-	Same as above (Public sewage)
		Pasture, range and paddock	Pasture, range and paddock	Same as above (Pasture, range and paddock)
		Other	Other system	Treated with method not mentioned above

Composting ("Composting" and "Piling") is widely practiced in Japan because, among other things: (1) it is essential for Japanese livestock farmers to facilitate transportation and handling, because the lack of space required for the on-site reduction of manure makes it necessary to direct the manure for

uses outside their farms; and (2) compost is in considerably higher demand as a fertilizer for various crops than slurry or liquid manure in Japan where fertilizers tend to be lost by heavy rain and the expectations of the protection of water quality, prevention of odor, and sanitary management are high.

"Anaerobic Lagoons" have been reported as "NO". Because there are quite small number of livestock farmers who has enough area of field to spread manure, and it is assumed that there are no livestock farmers who use anaerobic lagoons. There are cases when manure is spread to fields in Japan, but even in these cases, stirring is conducted before the spreading. Therefore, there are no anaerobic manure management systems.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of the CH_4 emission factors, Tier 2 values (20%) described in the *2006 IPCC Guidelines* were applied. For N_2O emission factors, uncertainty was calculated by synthesis of default uncertainties of each parameter described in the *2006 IPCC Guidelines* uncertainty.

For the uncertainties of the activity data, 1% (the standard error for swine given in the *Livestock Statistics*) was applied to swine, and 9% (the standard error for boiler given in the *Livestock Statistics*) was applied to poultry. For cattle, 1% is adopted, same as "Enteric Fermentation, Cattle".

As a result, the uncertainties of the emissions for dairy cattle, non-dairy cattle and swine were determined to be -20% to +20% for CH_4 and -71% to +112% for N_2O, and emissions for poultry were determined to be -22% to +22% for CH_4 and -72% to +112% for N_2O.

- ***Time-series Consistency***

Emission factors were used consistently from FY1990 onward by the method. Activity data were calculated consistently from FY1990 onward from the data in the *Livestock Statistics*.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1. For some country specific emission factors, there were significant differences between the default emission factors. In the case, the factors of differences were analyzed. QA/QC activities are summarized in Chapter 1.

Country-specific emission factors are used for CH_4 and N_2O emission factors for grazing cattle, and these values are lower than the value calculated from the default data described in the *2006 IPCC Guidelines*. It is guessed that andosol and brown forest soil, which drainage is well, are dominant for grazing land in Japan. Therefore, CH_4 and N_2O emission factors are low in Japan.

Country-specific emission factors are used for CH_4 and N_2O emission factors by pit storage for dairy cattle, and these values are lower than the value calculated from the default data described in *2006 IPCC Guidelines*. For CH_4, it is guessed that long term pit storage of slurry is not practiced comparatively in Japan, and before CH_4 emissions from slurry becomes further active, the stored slurry is spread to agriculture and grazed meadow soil. For N_2O, it is guessed that storage management covered by scum, which is guessed as N_2O source, is not dominant in Japan, and its management makes low emission factors.

For emission factors by piling for poultry, hen's EF is higher than broiler's one. For CH_4, the reason is guessed to be that moisture content of manure for hen is higher than broiler's. Country-specific emissions factors of N_2O by pilling for poultry is lower than the default emission factors. The reason is guessed to be that the default emission factors include not only poultry but also other animals (such as cattle and swine) (Nitrification is less likely to occur in poultry manure than cattle or swine manure).

Country-specific emissions factors of N_2O for sun drying of poultry is lower than the default emission factors. The reason is guessed to be that the default emission factors include not only poultry but also other animals which is the same reason for emission factors by piling for poultry.

e) Category-specific Recalculations

Since the emission factors for "pasture, range and paddock" of dairy cattle and non-dairy cattle were updated, the emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

As research on actual emissions and information collection for emission reduction method has been continuously conducted by the organizations and agencies concerned, a review of emission factors and parameters will be implemented when the new data are obtained.

5.3.2. Buffalo, Sheep, Goats, Horses, Rabbit and Mink (3.B.2., 3.B.4.)

a) Category Description

This section provides the estimation methods for CH_4 and N_2O emissions for manure management from buffalo, sheep, goats, horses, rabbit and mink.

b) Methodological Issues

- ***Estimation Method***

CH_4 and N_2O emissions were calculated by using the Tier 1 method in accordance with the decision tree of the *2006 IPCC Guidelines* (Vol. 4, Page 10.36, Fig 10.3 and Page 10.55, Fig. 10.4).

$$E_{CH4} = EF_{CH4} \times P$$

$$E_{N2O} = \Sigma(EF_{N2O\text{-}n} \times P \times Nex \times MS_n)$$

E_{CH4}	: CH_4 emissions associated with manure management [kg-CH_4]
E_{N2O}	: N_2O emission associated with livestock manure [kg-N_2O]
EF_{CH4}	: CH_4 emission factor [kg-CH_4 $head^{-1}$ $year^{-1}$]
$EF_{N2O\text{-}n}$	: N_2O emission factor of manure management *n* [kg-N_2O $(kg\text{-}N)^{-1}$]
P	: Livestock population [head]
Nex	: Nitrogen content in manure [kg-N $head^{-1}$]
MS_n	: Percentage of manure management *n* [%]

- ***Emission Factors***

For the emission factors for CH_4, the default values for temperate zones in industrialized nations, given in the *2006 IPCC Guidelines* were used. For buffalo, the default value given for the temperate zone in Asia was used.

For the emission factors for N_2O, the default values given in the *2006 IPCC Guidelines* were used.

Table 5-26 CH_4 emission factors for sheep, goats, horses, rabbit and mink

Type of livestock	Emission factors [kg-CH_4 $head^{-1}$ $year^{-1}$]	Reference
Sheep	0.28	*2006 IPCC Guidelines*, Vol. 4, p. 10.40, Table 10.15
Goats	0.20	
Horses	2.34	
Buffalo	2	*2006 IPCC Guidelines*, Vol. 4, p. 10.39, Table 10.14
Rabbit	0.08	*2006 IPCC Guidelines*, Vol. 4, p. 10.41, Table 10.16
Mink	0.68	

Table 5-27 N_2O 2mission factors for buffalo, sheep, goats, horses, rabbit and mink

Manure management category	[kg-N_2O-N (kg-N)$^{-1}$]
Dry lot	2.0%
Pasture Range and Paddock (buffalo)	2.0%
Pasture Range and Paddock (sheep, goats, horses)	1.0%
Daily Spread	0%
Burned for fuel	0%

Source: Drylot, Daily Spread: *2006 IPCC Guidelines* Vol.4, page 10.62, Table 10.21,
Pasture Range and Paddock: page 11.11, Table 11.1

- ***Activity Data***

For livestock population for sheep, goats, horses and buffalo, same data described in '3.A. Enteric Fermentation' are used (See Table 5-12). For rabbit and mink, population data in the *Statistical Document for small animals and laboratory animals* by MAFF are used (See Table 5-28 below).

For N_2O, in order to determine the total nitrogen amount for each livestock, first, it was calculated by multiplying the population of each type of animal by the nitrogen content of manure per head of animal (or by the nitrogen amount in manure per weight and livestock weight). Then, the amount of nitrogen per manure management category was calculated by multiplying the total nitrogen by the percentage of each management category. For the percentage of manure management category for baffalo, the default values given in the *2006 IPCC Guidelines* were used (classification is "Asia"). For rabbit and mink, which default values are not described in the *2006 IPCC Guidelines*, it is considered by expert judgment that all manure are managed by "Drylot". For sheep, goats and horses, the *2006 IPCC Guidelines* (Vol. 4, p.10.61) described that "Manure from other animal categories is typically managed in pasture and grazing operations". Therefore, it is assumed that their livestock manure are managed by grazing system.

Table 5-28 Livestock population for rabbit and mink [1000 heads]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Rabbit	15	16	21	19	19	19	18	18	18	18	18	18	18
Mink	155	11	6	1	1	1	1	1	1	1	1	1	1

Source: *Statistical Document for small animals and laboratory animals*, MAFF

Table 5-29 Body weight and N excretion rate for buffalo, sheep, goats, horses, rabbit and mink (Nex)

Type of animal	Body weight [kg]	N excretion rate per weight [kg-N (1000kg-body weight)$^{-1}$ day^{-1}]	N excretion rate [kg-N head^{-1} year^{-1}]
Buffalo	380	0.32	(44.4)
Sheep	48.5	1.17	(20.7)
Goats	38.5	1.37	(19.3)
Horses	377	0.46	(63.3)
Rabbit	-	-	8.1
Mink	-	-	4.59

Source: *2006 IPCC Guidelines* Vol.4, Table 10A-9 and Table 10A-6,
2006 IPCC Guidelines Vol.4, page 10.59, Table 10.19

Table 5-30 Percentage of each manure management category for buffalo (MS_n)

Manure management category	Percentage
	Buffalo
Lagoons	0%
Liquid /Slurry	0%
Solid Storage	0%
Drylot	41%
Pasture Range and Paddock	50%
Daily Spread	4%
Digeter	0%
Burned for Fuel	5%
Other	0%

Source: *2006 IPCC Guidelines*, Vol.4, Table 10A-6

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

An uncertainty assessment was conducted for individual livestock categories. With respect to the uncertainties for emission factors for CH_4, Tier 1 default value (30%) described in the *2006 IPCC Guidelines* was applied. For N_2O, the uncertainty was calculated by synthesis of default values of each parameter described in the *2006 IPCC Guidelines*. For the activity data, uncertainty was substituted by the value of broiler (9%) described in the *Livestock Statistics*. As a result, the uncertainties of the emissions were determined to be -31% to +31% for CH_4, and -72% to +112% for N_2O for each livestock.

- ***Time-series Consistency***

For emission factors, same values were used consistently for all the years. For Activity data were calculated consistently for all the years from the data in the *Statistical Document of Livestock Breeding*, the *Statistical Document of Horse*, the L*ivestock Statistics of Okinawa* and the *Status Report regarding Health Management for Livestock Feeding*.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since activity data (livestock population) were updated for sheep, goats and horses, the emissions from FY2010 to FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no improvement plans.

5.3.3. Other Livestock (3.B.4.-)

Deer, reindeer, fox, and others poultries (duck, turkey, etc.) ,which are other livestock than those listed above, are reported in the *Statistical Document for Small Animals and Laboratory Animals* by MAFF. However, their population size is small, and their each emission was lower than 3000t-CO_2 equivalent, which is the threshold to estimate in this GHG inventory decided by the Committee for GHG Emissions Estimation Methods. Therefore, it was reported as "NE" as considered insignificant (See Annex 5).

5.3.4. Indirect N_2O emissions (3.B.5.)

5.3.4.1. Atmospheric Deposition (3.B.5.-)

a) Category Description

This section provides the estimation methods for N_2O indirect emissions caused by atmospheric deposition of nitrogen volatilized as NH_3 and NOx from livestock manure management.

b) Methodological Issues

- ***Estimation Method***

N_2O emissions have been calculated by Tier 2 method in accordance with decision tree of the *2006 IPCC Guidelines* (Vol.4, Page 10.55, Fig. 10.4).

$$E = N_{Volatilizaiton\text{-}MMS} \times EF \times 44/28$$

E	: N_2O emissions by atmospheric deposition in the process of livestock manure management [kg-N_2O]
$N_{Volatilizaiton\text{-}MMS}$	: Nitrogen amount volatilized as NH_3 and NOx in the process of livestock manure management [kg (NH_3-N+NO_X-N)]
EF	: Emission factor [kg-N_2O-N/kg (NH_3-N+NO_X-N)]

- ***Emission Factors***

0.010 [kg-N_2O-N/kg-NH_3-N & NO_X-N deposited] (default value, *2006 IPCC Guidelines*, Vol.4 Table11.3).

- ***Activity Data***

For cattle, swine, and poultry (hen and broiler), as described in the following equation, amount of nitrogen that volatilized as ammonia and nitrogen oxides from livestock manure management ($N_{Volatilizaiton\text{-}MMS}$) is calculated using the nitrogen amount included in each manure management system (N_{Bi}) which calculated in the above 5.3.1., and volatilization rate as NH_3 and NOx from manure in each livestock barn ($Frac_{GASM1i}$) and in each process of treatment ($Frac_{GASM2i}$). The volatilization rate as NH_3 and NOx from manure are estimated from data described in the “Estimation of Nitrogen Loading in Japanese Prefectures and Scenario Testing of Abatement Strategies”, Hojito et al., (2003) (Reference 58) (See Table 5-31). For “Purification”, it is considered that there are not

volatilized in treatment process. Indirect N_2O emissions form grazing animal are reported in 3.D.b.1.

$$N_{Volatilizaiton\text{-}MMS} = \Sigma\{N_{Bi} \times (Frac_{GASM1i} + Frac_{GASM2i})\}$$

$N_{Volatilizaiton\text{-}MMS}$: Nitrogen amount volatilized as NH_3 and NOx in the process of livestock manure management [kg (NH_3-N+NO_X-N)]

N_{Bi} : Nitrogen amount in livestock manure for management system *i* [kg-N]

$Frac_{GASM1i}$: Volatilization rate as NH_3 and NO_X in livestock barn for management system *i* [kg-NH_3-N + NO_X-N/kg-N]

$Frac_{GASM2i}$: Volatilization rate as NH_3 and NO_X in process of treatment for management system *i* [kg-NH_3-N + NO_X-N/kg-N]

Table 5-31 Volatilization rate as NH_3 and NOx from manure (in livestock barn and in process of treatment)

Livestock	Treatment		Volatilization rate in livestock barn ($Frac_{GASM1}$)	Volatilization rate in process of treatment ($Frac_{GASM2}$)
Dairy cattle	Feces	Other than Composting	10.3%	13.7%
		Composting	10.3%	1.9%
	Urine	Other than Purification	10.3%	11.0%
		Purification	10.3%	0%
	Mixed	Other than Purification, Pit storage, Methane fermentation	4.5%	13.7%
		Purification	10.3%	0%
		Pit storage, Methane fermentation	10.3%	10.8%
Non-dairy cattle	Feces	Other than Composting	6.38%	13.7%
		Composting	6.38%	1.9%
	Urine	Other than Purification	6.38%	11%
		Purification	6.38%	0%
	Mixed	Other than Purification, Pit storage, Methane fermentation	6.38%	13.7%
		Purification	6.38%	0%
		Pit storage, Methane fermentation	6.38%	10.8%
Swine	Feces	All management	14.7%	19.7%
	Urine	Other than Purification	14.7%	27.0%
		Purification	14.7%	0%
	Mixed	Other than Purification, Pit storage, Methane fermentation	15.8%	24.2%
		Purification	14.7%	0%
		Pit storage, Methane fermentation	14.7%	25.0%
Hen and Broiler	Feces	All management	8.4%	51.5%

Source: Established from *"Estimation of Nitrogen Loading in Japanese Prefectures and Scenario Testing of Abatement Strategies"* (Hojito et al. (2003)) (Reference 58)

For buffalo, rabbit, and mink, nitrogen amount volatilized as NH_3 and NOx from manure were estimated by multiplying total nitrogen amount of manure of each livestock by default volatilization rate described in the *2006 IPCC Guidelines* (Other-Solid storage: 12%).

Table 5-32 Nitrogen amount volatilized as NH_3 and NOx in the process of livestock manure management [kt (NH_3-N+NO_X-N)]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Dairy cattle	33.3	31.5	28.5	26.2	25.3	24.5	23.9	23.4	23.0	22.9	22.5	21.9	21.5
Non-dairy cattle	26.8	27.8	26.8	26.3	26.8	27.7	27.9	27.6	26.4	26.1	25.2	24.5	23.8
Swine	43.6	38.1	37.0	33.8	33.8	33.3	33.2	32.4	32.1	32.1	31.9	31.4	31.4
Poultry (Hen, Broiler)	187.6	177.5	166.9	161.2	165.8	164.3	163.8	166.2	168.6	171.3	172.4	174.7	174.7
Other livestocks (Buffalo, Mink, Rabbit)	0.10	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total	291.5	274.9	259.3	247.5	251.7	249.8	248.8	249.6	250.1	252.5	251.9	252.5	251.3

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

Uncertainty (-106% to +447%) described in “Agricultural Soils (Atmospheric Deposition)” below was applied.

- ***Time-series Consistency***

For emission factors, consistent values (default values) were used in all time series. For activity data, constant value for volatilized factor and constant estimation method for manure amount calculated in 5.3.1. were used.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculation.

f) Category-specific Planned Improvements

Refer to the section” 5.3.1. Cattle, Swine and Poultry (Hen and Broiler)”.

5.3.4.2. Nitrogen Leaching and Run-off (3.B.5.-)

In Japan, under the "*Act on the Appropriate Treatment and Promotion of Utilization of Livestock Manure*", taking some measures to prevent from flowing wastewater in manure management, such as introducing concrete-clad floor, or using waterproof sheet, is required; so, the possibility of nitrogen leaching and run-off to subsurface water is very low. Therefore, this source is reported as “NO”.

5.4. Rice Cultivation (3.C.)

CH_4 is generated under anaerobic conditions by microbes activity. Therefore, paddy fields provide favorable conditions for CH_4 generation. In Japan, all paddy fields are irrigated, and intermittently and continuously flooded paddy fields are targeted in this category. In Japan, rice cultivation is practiced mainly on intermittently flooded paddy field.

CH_4 emissions from rice cultivation in FY2014 are 17,904 kt-CO_2 eq., comprising 1.3% of total emissions (excluding LULUCF). The value represents an increase by 3.5% from FY1990. Main driver of the emission increase from FY1990 is an increase of amount of organic matter application.

Table 5-33 CH_4 emissions from rice cultivation

Gas	Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	3.C.1.- Continuously flooded	kt-CH_4	96.2	104.3	95.8	100.7	97.4	98.9	102.7	97.6	103.8	104.2	103.4	103.5	102.8
	3.C.1.- Intermittently flooded	kt-CH_4	595.5	613.2	572.8	589.9	576.8	601.5	610.3	597.2	639.7	625.7	613.3	619.4	613.4
	Total	kt-CH_4	691.8	717.4	668.5	690.6	674.3	700.5	713.0	694.8	743.6	729.9	716.6	722.9	716.2
		kt-CO_2eq	17,294	17,936	16,714	17,265	16,856	17,511	17,825	17,371	18,589	18,248	17,916	18,073	17,904

5.4.1. Irrigated (Intermittently Flooded (Single Aeration) and Continuously Flooded)(3.C.1.)

a) Category Description

This section provides the estimation methods for CH_4 emissions from intermittently flooded and continuously flooded rice cultivation.

- ***Water management regime in Japanese paddy fields***

The general practice of intermittent flooding (single aeration) by paddy farmers in Japan is different in nature from the intermittently flooded paddy field (multi aeration) concept in the *2006 IPCC Guidelines*. The diagram below presents the outline.

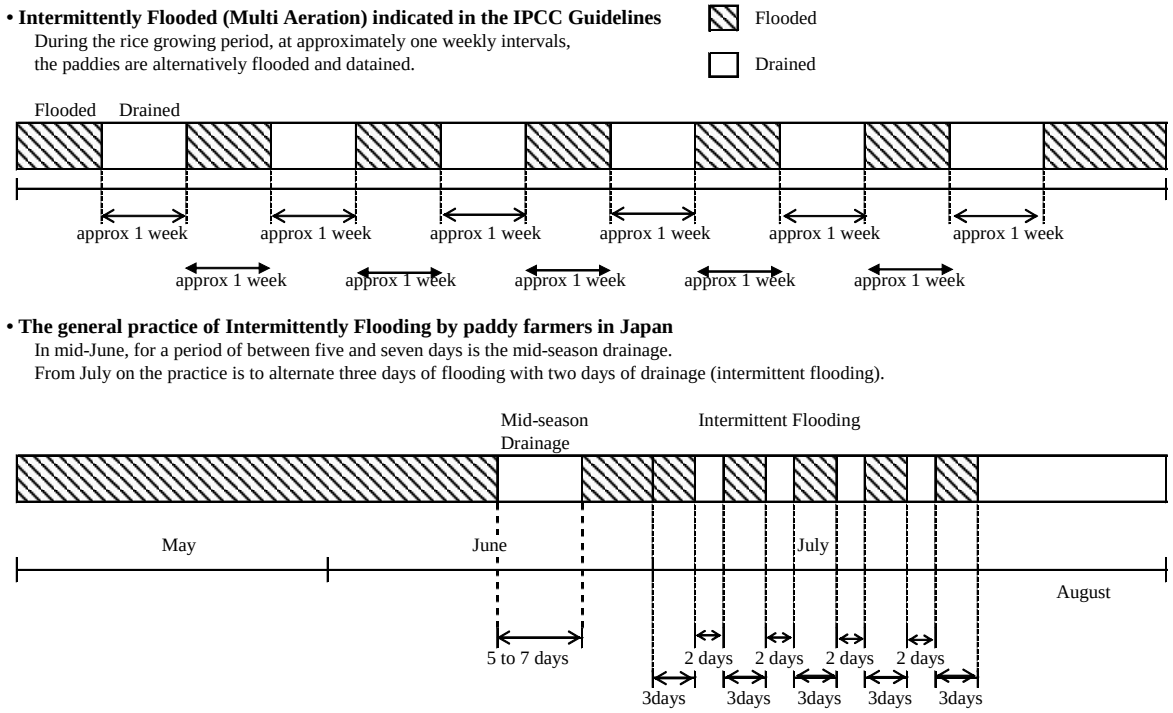

Figure 5-4 Comparison of water management regime in Japan and intermittent flooding (multi aeration) indicated in the *2006 IPCC Guidelines*

b) Methodological Issues

- ***Estimation Method***

Based on the calculation method in the *2006 IPCC Guidelines*, the emissions were estimated using emission factors established by the calculation using DeNitrification-DeComposition-Rice model (DNDC-Rice model) (Reference 60), which is the mathematical model to estimate change of CH_4 emissions with methods of organic matter application and/or water regime on paddy field, and the following formula determined by its model. Tier3 method was used to establish emission factor, and modified Tier2 method was used to estimate emissions.

Estimation method used in this section was developed through discussion in the Committee for Greenhouse Gas Emissions Estimation Methods on the basis of a paper of Katayanagi et al. (2016) (Reference67) and relevant paper.

$$E = \Sigma_{i,j,k,l} \{(A_i \times f_{Di,j} \times f_{Wi,k} \times f_{Ol}) \times EF_{i,j,k,l}\} \times 16/12$$

$$EF = aX + b$$

E	: CH_4 Emissions from paddy field [$kgCH_4$]
i	: Region (7 regions)
j	: Type of drainage (Poorly drained, one day drained, 4 hour drained)
k	: Type of water regime (Intermittently flooded, continuously flooded)
l	: Type of organic matter application (rice straw, compost, non-amendment)
A_i	: Crop area of rice paddy field by region
f_D	: Proportion of drainage
fw	: Proportion of water regime
f_O	: Proportion by type of organic matter application
EF	: EFs by region, drainage, water regime, organic matter management method [$kgCH_4$-C/ha/year]
X	: Amount of organic matter
a	: Slope (estimated by regression formula with CH_4 emissions calculated by the DNDC-Rice model and amount of organic matter)
b	: Intercept (estimated by regression formula with CH_4 emissions calculated by the DNDC-Rice model and amount of organic matter)

- ***Emission Factors***

The DNDC-Rice model was used to calculate the emission factor. The improved model, the DNDC-Rice model is based on the DNDC model and has developed in Japan so as to estimate CH_4 emissions from rice paddy field in Japan (Reference 60). Figure 5-5 is a conceptual scheme of the DNDC-Rice model.

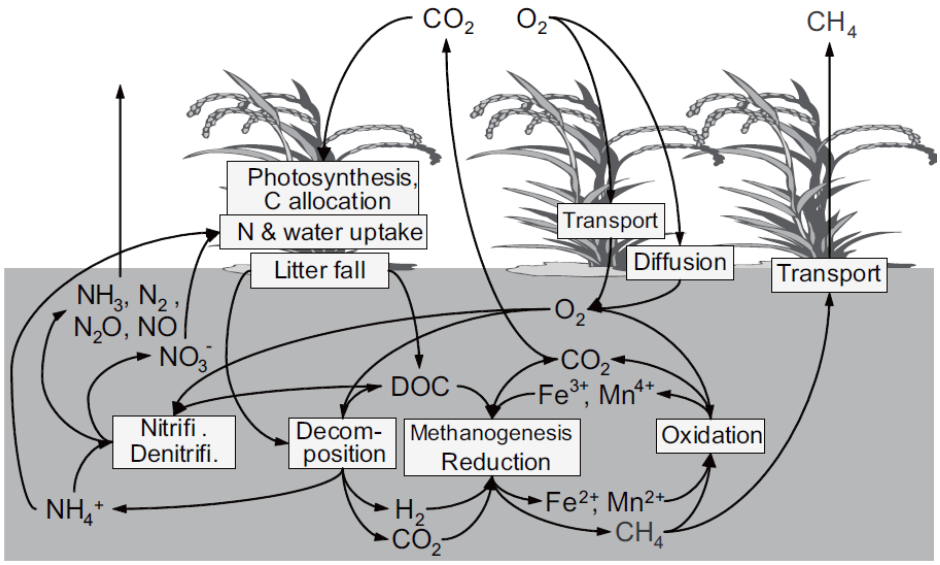

Figure 5-5 Conceptual scheme of the DNDC-Rice model

Reference: Fumoto et al. (2010) (Reference 60)

EFs were established on the basis of the information on nationwide 986 points of paddy field. The input data are soil (soil organic carbon content, pH, clay content, dry density, etc.), field drainage (maximum drainage rate), meteorological data (temperature, precipitation), and field management information (the day of transplantation, harvest date, plowing date, tillage method, fertilization date, fertilizer amount, organic matter application date, amount of organic matter application, organic C/N ratio, flooded date, drained date). The following are input data and references.

- Soil physical and chemical properties: data in 986 points described in the *First and Second Survey of the Soil Environment Basic Survey* (MAFF), which includes all data needed to be input in the DNDC-Rice model
- Field drainage: Maximum drainage rate of survey sites were set as 15 mm day^{-1}, 10 mm day^{-1} and 5 mm day^{-1} based on the data provided in "Flooded Situation" (4 hours drained, one day drained, poor drainage) in the *Fourth-Order Land Use Infrastructure Basic Survey* (MAFF)
- Meteorological data: Daily lowest temperature, daily highest temperature, and precipitation of the nearest AMeDAS point from each survey site were used.
- Field management information: data set created by Hayano et al. (2013) (Reference 63) which were divided the whole Japan to 136 region in accordance to the primary subdivision area by Japan Meteorological Agency and included cultivated history on the basis of the data published by Japan Agricultural Cooperatives or similar organization in each region were used.
- Amount of organic matter application: By using the method described by Yagasaki and Shirato (2014) (Reference 64), application amount of compost and crop residue (e.g. rice straw) plowed into soil by each prefecture in 1981 to 2010 were estimated. In other words, the average amount of crop residues plowed into soil such as rice straw were estimated by multiplying crop residue amount estimated from crop residue from prefecture harvest statistics of rice (and second crop such as wheat and fertilizer feed crops) by percentage plowed into the soil, then, by dividing the value by the rice cropping area. For amount of compost application, the average application amount by each year were estimated by the survey results of *"Basis Survey of Soil Environment"* by MAFF and *"Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration"* by Research council on Soil function for global warming countermeasures, etc.

Using the DNDC-Rice model and the above input data, CH_4 flux of each 986 points from 1981 to 2010 (30 years) were estimated by total 8 scenario (water management 2 scenario (intermittently flooded and continuously flooded) and organic matter applied 4 scenario (straw and compost[1], rice straw only, compost only, non-organic matter). Taking into account statistical significant difference of their results, CH_4 flux were sorted out by seven regions, drainage (3 levels), water regime, and organic matter application, and estimated averages of each year by each classification. In addition, the regression equation (linear function) to predict CH_4 flux (mean values for each year of each category) were determined by amount of organic matter application. intercept "b" of the regression equation were fixed to the CH_4 emissions flux estimated non-organic application scenario.

Total amount of organic matter application in region level were aggregated by prefecture which was estimated by the method described by Yagasaki and Shirato (2014). In addition, to induce amount of organic matter application (X) which are used in estimation in the inventory, their total amount and proportion of organic matter management (Table 5-39) were used. Amount of organic matter application in each input segment by region and the emission factor of each segment calculated these input, and they are shown in Table 5-34, and Table 5-35 below, respectively.

[1] The application scenario "straw and compost" was constructed in the model. However, its scenario is not used for inventory emission estimation.

Table 5-34 Amount of organic matter application by region (X) [tC/ha]

Item		1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Rice straw	Hokkaido	2.72	3.15	3.43	3.84	3.74	3.44	3.47	3.17	3.74	3.66	3.45	3.40	3.48
	Tohoku	2.84	3.17	3.61	3.65	3.58	3.71	3.44	3.56	3.88	3.52	3.36	3.38	3.42
	Hokuriku	3.86	3.82	4.33	3.36	3.35	3.45	3.25	3.41	4.63	4.31	3.20	3.23	3.17
	Kanto	2.84	3.11	3.65	3.65	3.42	3.54	3.42	3.49	3.61	3.41	3.27	3.34	3.25
	Tokai and Kinki	3.18	3.54	3.96	4.02	3.82	3.95	3.75	3.78	4.05	3.70	3.62	3.68	3.51
	Chugoku and Shikoku	3.01	3.55	3.87	3.79	3.35	3.75	3.66	3.47	3.91	3.67	3.46	3.43	3.28
	Kyusyu and Okinawa	2.80	2.76	3.04	2.79	2.44	2.92	3.19	2.93	3.14	2.65	2.78	2.76	2.73
Compost	Hokkaido	1.24	0.61	0.68	1.79	2.01	2.23	2.72	2.33	2.23	2.63	2.52	2.52	2.52
	Tohoku	1.24	0.61	0.68	1.79	2.01	2.23	2.72	2.33	2.23	2.63	2.52	2.52	2.52
	Hokuriku	1.25	0.61	0.68	1.79	2.01	2.23	2.72	2.33	2.23	2.63	2.52	2.52	2.52
	Kanto	1.35	0.73	0.72	2.13	2.39	2.64	3.22	2.73	2.59	3.08	2.94	2.93	2.93
	Tokai and Kinki	1.25	0.61	0.68	1.81	2.03	2.26	2.76	2.35	2.24	2.66	2.54	2.54	2.54
	Chugoku and Shikoku	1.33	0.66	0.70	1.94	2.16	2.37	2.91	2.50	2.40	2.84	2.72	2.71	2.71
	Kyusyu and Okinawa	1.55	0.93	0.84	2.84	3.26	3.69	4.56	3.89	3.69	4.55	4.33	4.30	4.28

Table 5-35 CH_4 emission factors in each segment [$kgCH_4$-C/ha]

Item			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Poorly drained field, Continuously flooded	Rice straw	Hokkaido	854	970	1,046	1,158	1,131	1,051	1,058	976	1,130	1,109	1,052	1,038	1,061
		Tohoku	933	1,021	1,139	1,150	1,131	1,166	1,095	1,127	1,211	1,116	1,074	1,079	1,088
		Hokuriku	1,014	1,004	1,123	896	894	918	871	908	1,193	1,118	860	867	852
		Kanto	369	402	467	468	440	455	440	448	463	438	421	430	419
		Tokai and Kinki	668	741	823	835	795	823	782	788	841	771	757	767	733
		Chugoku and Shikoku	671	779	841	825	738	817	799	762	849	801	760	754	725
		Kyusyu and Okinawa	356	351	385	355	312	371	403	372	398	338	353	352	347
	Compost	Hokkaido	452	279	298	600	660	721	855	747	720	830	799	799	799
		Tohoku	506	337	355	652	711	771	903	796	770	879	848	848	848
		Hokuriku	404	254	271	530	582	633	748	655	633	727	700	700	700
		Kanto	184	108	106	280	312	344	415	354	337	397	381	379	379
		Tokai and Kinki	285	157	170	395	440	486	584	503	482	564	541	541	541
		Chugoku and Shikoku	339	208	215	461	504	545	652	572	552	638	613	613	613
		Kyusyu and Okinawa	205	129	117	361	411	464	570	489	464	569	542	538	536
	No-amendment	Hokkaido	114	114	114	114	114	114	114	114	114	114	114	114	114
		Tohoku	175	175	175	175	175	175	175	175	175	175	175	175	175
		Hokuriku	113	113	113	113	113	113	113	113	113	113	113	113	113
		Kanto	18	18	18	18	18	18	18	18	18	18	18	18	18
		Tokai and Kinki	35	35	35	35	35	35	35	35	35	35	35	35	35
		Chugoku and Shikoku	77	77	77	77	77	77	77	77	77	77	77	77	77
		Kyusyu and Okinawa	16	16	16	16	16	16	16	16	16	16	16	16	16
Poorly drained field, Intermittently flooded	Rice straw	Hokkaido	854	970	1,046	1,158	1,131	1,051	1,058	976	1,130	1,109	1,052	1,038	1,061
		Tohoku	903	990	1,107	1,117	1,099	1,134	1,064	1,095	1,178	1,084	1,042	1,047	1,057
		Hokuriku	777	769	867	680	678	698	659	690	926	864	651	656	644
		Kanto	332	362	420	421	395	409	396	403	416	394	379	386	377
		Tokai and Kinki	544	605	672	682	649	672	639	643	687	629	618	626	598
		Chugoku and Shikoku	608	709	766	751	670	744	728	692	774	729	690	685	658
		Kyusyu and Okinawa	306	302	331	305	269	319	347	320	341	291	304	303	299
	Compost	Hokkaido	452	279	298	600	660	721	855	747	720	830	799	799	799
		Tohoku	481	314	332	625	684	743	873	768	742	849	819	819	819
		Hokuriku	273	150	163	378	420	463	558	481	463	541	519	519	519
		Kanto	166	98	97	252	281	309	373	319	303	357	342	341	341
		Tokai and Kinki	228	122	133	319	356	393	475	407	390	458	439	439	439
		Chugoku and Shikoku	300	179	185	413	453	491	591	516	497	578	555	554	554
		Kyusyu and Okinawa	178	114	104	310	353	398	487	419	398	487	464	461	458
	No-amendment	Hokkaido	114	114	114	114	114	114	114	114	114	114	114	114	114
		Tohoku	153	153	153	153	153	153	153	153	153	153	153	153	153
		Hokuriku	33	33	33	33	33	33	33	33	33	33	33	33	33
		Kanto	17	17	17	17	17	17	17	17	17	17	17	17	17
		Tokai and Kinki	21	21	21	21	21	21	21	21	21	21	21	21	21
		Chugoku and Shikoku	57	57	57	57	57	57	57	57	57	57	57	57	57
		Kyusyu and Okinawa	19	19	19	19	19	19	19	19	19	19	19	19	19

Table 5-35 CH_4 emission factors in each segment [$kgCH_4$-C/ha] (Continue)

Item			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
One day drained field, Continuously flooded	Rice straw	Hokkaido	515	590	639	711	694	642	647	594	693	679	643	634	648
		Tohoku	697	764	854	862	848	874	821	845	909	836	804	808	815
		Hokuriku	777	769	866	682	680	700	661	691	923	862	653	658	646
		Kanto	242	263	305	306	287	297	287	292	302	286	275	281	274
		Tokai and Kinki	308	343	383	388	369	382	363	366	391	358	351	356	340
		Chugoku and Shikoku	274	321	348	341	303	338	330	314	352	331	313	310	298
		Kyusyu and Okinawa	298	294	323	297	261	311	338	312	333	283	296	294	291
	Compost	Hokkaido	256	145	157	352	390	429	516	446	429	500	480	480	480
		Tohoku	372	242	257	483	528	573	674	593	573	655	632	632	632
		Hokuriku	282	161	174	385	426	468	562	486	468	545	523	523	523
		Kanto	123	74	74	185	206	226	271	232	221	260	249	248	248
		Tokai and Kinki	126	64	71	178	200	221	269	230	220	259	248	248	248
		Chugoku and Shikoku	130	74	77	183	202	220	266	231	223	260	249	249	249
		Kyusyu and Okinawa	171	107	98	302	345	389	478	410	389	477	455	451	449
	No-amendment	Hokkaido	39	39	39	39	39	39	39	39	39	39	39	39	39
		Tohoku	119	119	119	119	119	119	119	119	119	119	119	119	119
		Hokuriku	46	46	46	46	46	46	46	46	46	46	46	46	46
		Kanto	17	17	17	17	17	17	17	17	17	17	17	17	17
		Tokai and Kinki	6	6	6	6	6	6	6	6	6	6	6	6	6
		Chugoku and Shikoku	17	17	17	17	17	17	17	17	17	17	17	17	17
		Kyusyu and Okinawa	12	12	12	12	12	12	12	12	12	12	12	12	12
One day drained field, Intermittently flooded	Rice straw	Hokkaido	358	411	446	497	484	448	451	414	484	474	448	442	452
		Tohoku	502	552	619	625	615	635	595	613	660	606	582	585	590
		Hokuriku	564	558	629	495	493	508	480	502	671	626	474	477	469
		Kanto	177	193	223	223	210	217	210	214	221	209	201	205	201
		Tokai and Kinki	139	155	172	175	167	172	164	165	176	161	158	160	153
		Chugoku and Shikoku	149	175	190	186	165	184	180	170	192	180	170	169	162
		Kyusyu and Okinawa	170	168	184	170	149	177	193	178	190	161	169	168	166
	Compost	Hokkaido	175	96	105	242	270	297	359	309	297	347	333	333	333
		Tohoku	259	163	173	342	376	410	485	424	410	471	454	454	454
		Hokuriku	203	115	124	278	308	339	407	352	339	395	379	379	379
		Kanto	91	56	56	136	151	165	199	170	162	190	183	182	182
		Tokai and Kinki	56	29	32	80	90	100	121	103	99	117	112	112	112
		Chugoku and Shikoku	68	37	38	98	108	118	144	125	120	141	135	134	134
		Kyusyu and Okinawa	97	61	55	172	197	222	273	234	222	273	260	258	256
	No-amendment	Hokkaido	21	21	21	21	21	21	21	21	21	21	21	21	21
		Tohoku	71	71	71	71	71	71	71	71	71	71	71	71	71
		Hokuriku	31	31	31	31	31	31	31	31	31	31	31	31	31
		Kanto	15	15	15	15	15	15	15	15	15	15	15	15	15
		Tokai and Kinki	2	2	2	2	2	2	2	2	2	2	2	2	2
		Chugoku and Shikoku	5	5	5	5	5	5	5	5	5	5	5	5	5
		Kyusyu and Okinawa	7	7	7	7	7	7	7	7	7	7	7	7	7
4 hour drained field, Continuously flooded	Rice straw	Hokkaido	465	533	577	643	627	580	584	536	626	614	581	573	586
		Tohoku	647	710	796	803	790	815	764	787	848	779	749	752	759
		Hokuriku	740	732	824	649	647	666	629	658	878	821	621	626	615
		Kanto	319	346	401	402	378	390	378	385	397	376	362	370	361
		Tokai and Kinki	327	364	404	410	391	404	384	387	413	379	372	377	360
		Chugoku and Shikoku	369	431	467	458	408	454	443	421	472	444	420	417	400
		Kyusyu and Okinawa	358	353	388	357	314	373	406	374	400	340	355	354	349
	Compost	Hokkaido	230	130	140	317	352	387	466	402	387	451	433	433	433
		Tohoku	337	214	228	443	486	529	625	547	528	607	585	585	585
		Hokuriku	268	152	165	366	406	445	535	463	445	518	497	497	497
		Kanto	165	102	101	245	272	298	357	307	292	343	329	327	327
		Tokai and Kinki	137	73	80	192	214	237	286	245	235	276	264	264	264
		Chugoku and Shikoku	178	103	107	248	273	296	359	312	300	350	336	336	336
		Kyusyu and Okinawa	205	127	116	363	414	468	575	493	468	574	547	543	540
	No-amendment	Hokkaido	33	33	33	33	33	33	33	33	33	33	33	33	33
		Tohoku	97	97	97	97	97	97	97	97	97	97	97	97	97
		Hokuriku	43	43	43	43	43	43	43	43	43	43	43	43	43
		Kanto	27	27	27	27	27	27	27	27	27	27	27	27	27
		Tokai and Kinki	13	13	13	13	13	13	13	13	13	13	13	13	13
		Chugoku and Shikoku	27	27	27	27	27	27	27	27	27	27	27	27	27
		Kyusyu and Okinawa	13	13	13	13	13	13	13	13	13	13	13	13	13

Table 5-35 CH_4 emission factors in each segment [$kgCH_4$-C/ha] (Continue)

Item			1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
4 hour drained field, Intermittently flooded	Rice straw	Hokkaido	261	300	325	363	354	327	329	302	353	346	327	322	330
		Tohoku	457	503	564	570	561	579	542	558	602	552	530	533	538
		Hokuriku	500	495	558	438	437	450	425	444	596	556	419	422	415
		Kanto	221	240	278	279	262	271	262	267	275	261	251	256	250
		Tokai and Kinki	184	205	228	231	220	228	216	218	233	213	209	212	203
		Chugoku and Shikoku	256	299	324	318	283	315	308	292	328	308	292	289	278
		Kyusyu and Okinawa	213	209	230	212	186	222	241	222	238	202	211	210	207
	Compost	Hokkaido	126	69	75	176	196	216	261	225	216	253	243	243	243
		Tohoku	233	144	154	310	341	372	441	385	371	428	412	412	412
		Hokuriku	177	97	106	244	271	298	360	310	298	348	334	334	334
		Kanto	113	68	68	169	188	206	248	212	202	237	228	227	227
		Tokai and Kinki	76	40	44	107	120	133	161	138	132	155	148	148	148
		Chugoku and Shikoku	123	70	73	171	189	205	248	216	208	243	233	233	232
		Kyusyu and Okinawa	121	75	68	215	246	278	342	293	278	341	325	323	321
	No-amendment	Hokkaido	14	14	14	14	14	14	14	14	14	14	14	14	14
		Tohoku	59	59	59	59	59	59	59	59	59	59	59	59	59
		Hokuriku	22	22	22	22	22	22	22	22	22	22	22	22	22
		Kanto	16	16	16	16	16	16	16	16	16	16	16	16	16
		Tokai and Kinki	6	6	6	6	6	6	6	6	6	6	6	6	6
		Chugoku and Shikoku	17	17	17	17	17	17	17	17	17	17	17	17	17
		Kyusyu and Okinawa	7	7	7	7	7	7	7	7	7	7	7	7	7

- ***Activity Data***

For area of paddy rice field by region (A), data described in the "*Statistics of Cultivated and Planted Area"* by MAFF were used. For drainage (f_D), proportion of water regime (f_w), proportion of organic matter (f_O), survey data by MAFF and etc. described in Table 5-36 to Table 5-39 were used respectively.

Table 5-36 Area of paddy fields by region (A) [kha]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Hokkaido	146	163	135	119	116	116	115	115	115	114	113	113	112
Tohoku	525	539	456	444	441	436	419	421	429	406	414	419	419
Hokuriku	258	260	221	218	217	216	211	211	213	213	213	215	216
Kanto	386	390	336	331	329	329	320	320	322	323	324	324	323
Tokai	117	116	95	91	90	89	88	87	88	88	88	87	86
Kinki	145	148	122	117	114	113	111	111	111	111	111	111	110
Chugoku and Shikoku	236	232	187	182	181	178	176	176	178	176	175	175	173
Kyusyu and Okinawa	246	251	207	206	204	200	196	196	202	202	203	203	201
Total	2,058	2,098	1,758	1,708	1,691	1,678	1,637	1,637	1,657	1,632	1,641	1,647	1,639

* On the estimation, Tokai and Kinki regions are aggregated as one region

Source: *Statistics of Cultivated and Planted Area* (MAFF) (Reference 10)

Table 5-37 Proportion of drainage (f_D)

Region	4 hour drained	One day drained	Poorly drained
Hokkaido	51%	42%	7%
Tohoku	63%	31%	6%
Hokuriku	69%	26%	4%
Kanto	59%	32%	9%
Tokai and Kinki	69%	23%	8%
Chugoku and Shikoku	65%	27%	8%
Kyusyu and Okinawa	74%	21%	5%

Source : MAFF "*Forth basic survey on infrastructure development of land use*"(Reference 61)

Table 5-38 Proportion of water regime (f_w)

Region	Continuously flooded	Intermittently flooded
Hokkaido	48%	52%
Tohoku	5%	95%
Hokuriku	4%	96%
Kanto	14%	86%
Tokai and Kinki	11%	89%
Chugoku and Shikoku	8%	92%
Kyusyu and Okinawa	7%	93%

Source : Research council on soil function for global warming countermeasures *"Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration"*(Reference 44)

Table 5-39 Proportion of organic matter management in Japan (f_O)

Item	1990~2007	2008	2009	2010	2011	2012	2013	2014
Straw amendment	60%	65%	61%	57%	62%	65%	65%	65%
Various compost amendment	20%	18%	23%	26%	22%	23%	23%	23%
No-amendment	20%	17%	16%	17%	16%	12%	12%	12%

Source : 1990-2007: MAFF, *"Basis Survey of Soil Environment"* (Reference 43)
After 2008: Research council on Soil function for global warming countermeasures, *"Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration"* (Reference 44)

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the emission factors, uncertainty (6%) was calculated by the DNDC-Rice model. For the uncertainty of the activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied. As a result, the uncertainties of the emissions were determined to be 6%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

Comparison of CH_4 emissions calculated by the DNDC-Rice model and emissions of actually measured data in the field was discussed and reported in the paper by Minamikawa et al. (2014) (Reference 62), Fumoto et al. (2010) (Reference 60), and Katayanagi et al. (2016) (Reference 67).

Figure 5-6 is comparison of annual methane emission between values observed and values simulated by the DNDC-Rice model described in Katayanagi et al. (2016). The Paper reports that simulated CH_4 emission was strongly and significantly correlated with the observations (r=0.861), reflecting the variations caused by differences among the sites and the treatments.

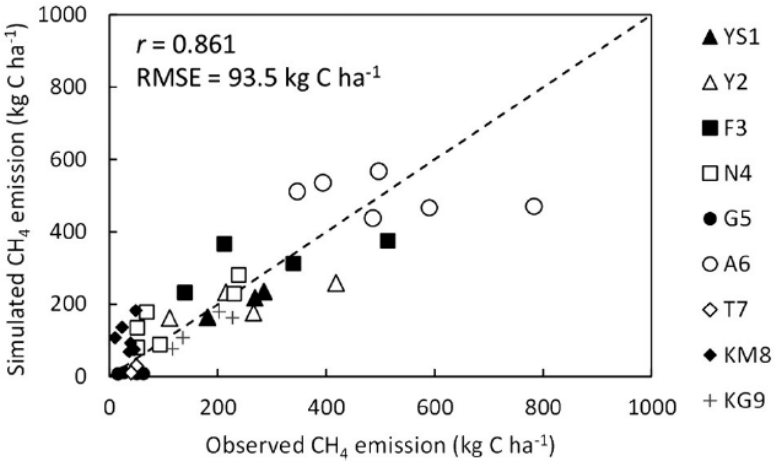

Figure 5-6 Comparison of annual methane emission between values obserbed and values simulated by the DNDC-Rice model

Source: Quoted from Figure 3 in Katayanagi et al. (2016) (Reference 67)

In addition, validation of application of the emission factors calculated by the DNDC-Rice model, into Japan's inventory has been conducted in Katayanagi et al. (2016) and also discussed in the Agriculture Breakout Group on the Committee of GHG Emission Estimation Methods.

e) Category-specific Recalculations

Since amount of organic matter application were updated, emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

In the future, if the research on the DNDC-Rice model progress and the model are improved and updated, application of the improved version will be considered.

5.4.2. Rainfed & Deep Water and Other (3.C.2., 3.C.3., 3.C.4.)

As indicated in the *World Rice Statistics 1993–94*, IRRI (International Rice Research Institute), rainfed and deep water paddy fields do not exist in Japan. Therefore, this category has been reported as "NO".

Just as indicated in the *World Rice Statistics 1993-94*, IRRI, a possible source of emissions for other paddy field is upland rice field, but since upland rice field are not flooded, like the soil of fields, they are aerobic. The bacteria that generate CH_4 are obligatory anaerobic bacterium, and unless the soil is maintained in an anaerobic state, CH_4 will not be emitted. As generation of CH_4 is not feasible, this category was reported as "NA".

5.5. Agricultural Soils (3.D.)

This section provides the estimation methods for N_2O direct emissions from soils (by applied

inorganic fertilizers, organic fertilizers, grazing livestock manure, crop residue, mineralization by soil carbon loss, and plowing of organic soil), and for N_2O indirect emissions (by atmospheric deposition, and nitrogen leaching and run-off).

N_2O emissions from agricultural soils in FY2014 are 5,720 kt-CO_2 eq., comprising 0.4% of total emissions (excluding LULUCF). The value represents a reduction by 21.2% from FY1990. Main drivers of the emission reduction from FY1990 are decreases of nitrogen amount applied to soil of inorganic fertilizer, and organic fertilizer from livestock manure.

Table 5-40 N_2O emissions from agricultural soils

Gas	Item		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N_2O	3.D.a. Direct emission	1. Inorganic N fertilizers	kt-N_2O	6.2	5.3	5.0	4.8	4.7	4.9	3.7	3.6	4.2	4.0	4.1	4.2	4.2
		2. Organic N fertilizers	kt-N_2O	5.5	5.3	5.0	4.6	4.7	5.1	4.8	4.5	4.8	4.8	4.7	4.7	4.7
		3. Manure by grazing animal	kt-N_2O	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
		4. residues	kt-N_2O	2.4	2.3	2.5	2.3	2.2	2.2	2.2	2.0	2.0	2.0	2.0	2.0	2.0
		5. Mineralization	kt-N_2O	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2
		6. Cultivation of organic soil	kt-N_2O	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	3.D.b. Indirect emission	1. Atmospheric deposition	kt-N_2O	2.7	2.6	2.4	2.2	2.3	2.4	2.1	2.0	2.2	2.2	2.2	2.2	2.2
		2. N leaching and run-off	kt-N_2O	5.5	5.1	4.9	4.7	4.6	4.9	4.3	4.1	4.4	4.4	4.3	4.4	4.4
	Total		kt-N_2O	24.4	22.5	21.7	20.4	20.3	21.4	18.9	18.1	19.4	19.1	19.1	19.3	19.2
			kt-CO_2eq	7,262	6,712	6,457	6,081	6,042	6,373	5,641	5,391	5,772	5,705	5,686	5,741	5,720

5.5.1. Direct Soil Emissions (3.D.a.)

Application of inorganic fertilizers, organic fertilizers, and grazing livestock manure, or plowing of crop residues into soil generates ammonium ions in the soil. The soil emits N_2O in the process of oxidizing the ammonium ions into nitrate-nitrogen under aerobic conditions. N_2O is also emitted via denitrification of nitrate. In addition, N_2O is generated when soil containing nitrogen is plowed.

5.5.1.1. Inorganic N Fertilizers (3.D.a.1.)

a) Category Description

This section provides the estimation methods for N_2O emissions by the application of inorganic synthetic fertilizers (synthetic fertilizers).

b) Methodological Issues

- ***Methodology for Estimating Emissions / Removals of GHGs***

N_2O emissions were calculated by Tier2 method, using country-specific emission factors in accordance with decision tree of the *2006 IPCC Guidelines* (Vol. 4, p11.9, Fig.11.2).

In addition, estimation method for N_2O emission reduction from agricultural soil using synthetic fertilizer with nitrification inhibitor is also established.

$$E = \sum_{ij} (F_{SNij} \times EF_{1ij}) \times 44/28$$

E : N_2O emissions associated with the application of synthetic fertilizer in agricultural soil (crop field) [kg-N_2O]

F_{SNij} : Nitrogen amount of synthetic fertilizer *j* applied to agricultural soil for crop type *i* [kg-N]

EF_{1ij} : Emission factor of synthetic fertilizer *j* for crop type *i* [kg-N_2O-N/kg-N]

i : Crop type

j : fertilizer type (with or without nitrification inhibitor)

- ***Emission Factors***

Emission factors were established based on actual data measurement conducted in Japan. Emission factors with nitrification inhibitor were established by multiplying their country-specific emission factor by N_2O reduction rate.

Emission factors for N_2O associated with the application of synthetic fertilizers and organic fertilizers were defined as the same value, because there was no significant difference between emission factors of synthetic fertilizers and organic fertilizers, analyzing data for N_2O emissions from agricultural fields in Japan.

Comparing emission factors among various crops, it was identified that emission factor of tea was significantly higher and emission factor of rice was significantly lower than those of other crops. As there were not significant differences among the other crops, three emission factors were defined (for rice, tea and other crops). Emission factor of Japan is lower than that of default value in the *2006 IPCC Guidelines*. It is the reason that the volcanic ash soil that is widely distributed in Japan releases little N_2O emissions. The emission factor of rice is adopted as a default value within the *2006 IPCC Guidelines* and its validity has been internationally confirmed.

N_2O emission reduction rate using synthetic fertilizer with nitrification inhibitor was decided as 26%, the lower limit of N_2O reduction rate using fertilizer with dicyanamide (26-36%) described in Akiyama et al. (2010) (Reference 66). On the other hand, since nitrification seldom occur on flooded situation in paddy rice field, synthetic fertilizer with nitrification inhibitor is never used. Therefore, EF with nitrification inhibitor for paddy rice was not developed.

Table 5-41 N_2O emission factor for synthetic fertilizer to agricultural soil

Crop species	Emission Factor without nitrogen inhibitor [kg-N_2O-N/kg-N]	Emission Factor with nitrogen inhibitor [kg-N_2O-N/kg-N]
Paddy rice	0.31 %	-
Tea	2.9 %	2.1 % [=2.9% × (1-0.26)]
Other species	0.62 %	0.46 % [=0.62%×(1-0.26)]

Source: Akiyama et al., Direct N_2O emissions and estimate of N_2O emission factors from Japanese agricultural soils. (2006) (Reference 33)
Akiyama et al., Estimations of emission factors for fertilizer-induced direct N_2O emissions from agricultural soils in Japan: Summary of available data (2006) (Reference 34)
Akiyama et al., Evaluation of effectiveness of enhanced-efficiency fertilizers as mitigation options for N_2O and NO emissions from agricultural soils: meta-analysis, Global Change Biology (2010) (Reference 66)

- ***Activity Data***

Total nitrogen amount of synthetic fertilizer described in "*Yearbook of Fertilizer Statistics (Pocket Edition)*" are used for estimation. To estimate amount of synthetic fertilizer applied to the agricultural soil, amount of synthetic fertilizer applied to forest are subtracted from this total amount (Table 5-42).

In addition, considering emission factors above, to estimate the amount of synthetic fertilizer applied by crop type, values corresponding to the amounts of nitrogen applied for each crop type are calculated by multiplying area of each crop field by the results of studies on the amounts of synthetic fertilizers applied per unit area for each crop type in Japan. Total synthetic fertilizer demand is apportioned to each crop type in accordance with the corresponding application amount for each crop type.

$$F_{SNi} = (F_T - F_{FRST}) \times \frac{(RA_i \times RF_i \times 10)}{\sum (RA_n \times RF_n \times 10)}$$

F_{SNi} : Nitrogen amount of synthetic fertilizer applied to agricultural soil for crop type i [t-N]
F_T : Total nitrogen amount of synthetic fertilizer [t-N]
F_{FRST} : Nitrogen amount of synthetic fertilizer applied to forest [t-N]
RA_i : Area of crop field for crop type i [ha]
RF_i : Nitrogen amount of synthetic fertilizer per area of crop field for crop type i [kg-N/10a]
RA_n : Area of crop field by each crop type [ha]
RF_n : Nitrogen amount of synthetic fertilizer per area of crop field by each crop type [kg-N/10a]

The amounts of fertilizer applied by crop type are known because the amounts of synthetic and organic fertilizers applied for each crop type were determined by a farming study conducted in 2000 (*Research Report on Methodologies for Quantification of GHG Emission Reduction in FY 2000* (Reference 22)). Because experts reason that there is likely little year-on-year change in application amounts to crops except for paddy rice and tea, data on the amounts of synthetic fertilizer applied per unit area according to the 2000 study (Reference 22) were applied uniformly for these crops in all the years.

Because of regulations and other factors, fertilizer application amounts for tea change from year to year. The amounts of nitrogen applied to tea fields (the total of synthetic and organic) in 1993, 1998, and 2002 investigated and summarized by Nonaka (2005) (Reference 39) and the ratio of synthetic fertilizer and organic fertilizer applied to tea according to the 2000 study (Reference 22) were used to estimate the amounts of synthetic and organic fertilizer applied. Time-series data were prepared by interpolating from 1993 to 2002, using the 1993 data for previous years, and using the 2002 data for subsequent years (see Table 5-45). For paddy rice, the report uses application amount data for years that can be determined using "*Yearbook of Fertilizer Statistics (Pocket Edition)*". The value of paddy rice was substituted for upland rice.

Shipping amount of synthetic fertilizer with nitrification inhibitor surveyed by MAFF data, which number was included in "N amount of synthetic N fertilizer applied (agricultural soil)", and 13% as nitrogen content in production, which is an average value of nitrogen content in production for major makers, was used. In addition, since synthetic fertilizer with nitrification inhibitor was not used for paddy rice nor feed crops, they were excluded from estimation.

Table 5-42 Nitrogen amount of synthetic fertilizer applied to soil [t-N]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total N amount of synthetic N fertilizer	611,955	527,517	487,406	471,190	453,774	479,034	360,056	350,135	409,590	387,201	396,783	409,918	409,918
N amounut of synthetic N fertilizer applied (forest soil)	288	248	229	222	238	216	157	165	193	182	187	193	193
N amounut of synthetic N fertilizer applied (agricultural soil)	611,667	527,269	487,177	470,968	453,536	478,818	359,899	349,970	409,397	387,019	396,596	409,725	409,725

* This amount includes synthetic fertilizer with nitrification inhibitor.
Source: Total: Yearbook of Fertilizer Statistics (Pocket Edition) (References 13)
Applied to forest: Estimated on the basis of Forestry Agency Survey

Table 5-43 Nitrogen amount of synthetic fertilizer with nitrification inhibitor [t-N]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N amount of synthetic N fertilizer with nitrification inhibitor	0	0	4,030	4,290	4,030	4,030	4,160	5,980	4,940	5,850	5,070	7,800	4,680

Source: Estimated from MAFF data and nitrogen contents (13%)

Table 5-44 Amount of synthetic fertilizers application per area by each type of crop (other than rice and tea)

Type of crop	Amount of application [kg-N/10a]
Vegetables	21.27
Fruit	14.70
Potatoes	12.70
Pulse	3.10
Feed crops	10.00
Sweet potato	6.20
Wheat	10.00
Coarse cereal (including Buckwheat)	4.12
Mulberries	16.20
Industrial crops	22.90
Tobacco	15.40

Source: Association for Advancement of Agricultural Science, *Research Report on Methodologies for Quantification of GHG Emission Reduction in FY 2000* (References 22)

Table 5-45 Amount of synthetic fertilizers application per area (rice and tea)

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Amount of synthetic N fertilizers application per area (rice)	9.65	8.71	7.34	6.62	6.46	6.27	6.47	5.80	5.95	5.93	6.04	6.10	6.10
Amount of synthetic N fertilizers application per area (tea)	57.23	54.88	48.06	44.76	44.76	44.76	44.76	44.76	44.76	44.76	44.76	44.76	44.76

Source: Rice: *Yearbook of Fertilizer Statistics (Pocket Edition)* (References 13)
Tea: Nonaka (2005) (References 45)

Table 5-46 Area of cropping by each type of crop [kha]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Vegetables	620.1	564.4	524.9	476.3	471.2	468.0	469.5	468.7	465.4	460.4	457.9	453.4	452.1
Paddy rice (for grain)	2,055.0	2,106.0	1,763.0	1,702.0	1,684.0	1,669.0	1,624.0	1,621.0	1,625.0	1,574.0	1,579.0	1,597.0	1,573.0
Fruit	346.3	314.9	286.2	265.4	261.8	258.4	254.7	250.7	246.9	243.5	240.3	237.0	233.8
Tea	58.5	53.7	50.4	48.7	48.5	48.2	48.0	47.3	46.8	46.2	45.9	45.4	44.8
Potatoes	115.8	104.4	94.6	86.9	86.6	87.4	84.9	83.1	82.5	81.0	81.2	79.7	78.3
Pulse	256.6	155.5	191.8	193.9	194.5	191.3	199.7	197.5	189.0	186.2	180.2	178.5	181.0
Feed crops	1,096.0	1,013.0	1,026.0	1,030.0	1,018.0	1,012.0	1,012.0	1,008.0	1,012.0	1,030.0	1,029.0	1,012.0	1,019.0
Sweet potato	60.6	49.4	43.4	40.8	40.8	40.7	40.7	40.5	39.7	38.9	38.8	38.6	38.0
Wheat	366.4	210.2	236.6	268.3	272.1	264.0	265.4	266.2	265.7	271.7	269.5	269.5	272.7
Coarse cereal (incl. buckwheat)	29.6	23.4	38.4	45.9	46.1	47.4	49.1	47.5	49.7	58.1	62.6	62.9	61.4
Mulberries	59.5	26.3	5.9	3.0	2.7	2.4	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Industrial crops	142.9	124.5	116.3	110.3	109.3	108.1	107.5	106.4	104.8	101.9	100.2	98.5	97.8
Tobacco	30.0	26.4	24.0	19.1	18.5	17.7	16.8	15.8	15.0	13.0	9.0	8.9	8.6
Upland rice	18.9	11.6	7.1	4.5	4.1	3.6	3.2	3.0	2.9	2.4	2.1	1.7	1.4

Source: Potatoes: MAFF, *Vegetable Production and Shipment Statistics*, Tobacco: Japan Tobacco Survey, Mulberries: MAFF Survey, Other crops: MAFF, *Statistics of Cultivated and Planted Area* (Note: The values of "Potatoes" is excluded in "Vegetable", and "Tea" and "Tobacco" is excluded in "Industrial crops".)

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the emission factors, uncertainty (31%) described in the reference of EFs, Akiyama et al. (2006), was applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 31%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission

factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1. Comparison with Japan's EF and the default EF in the IPCC Guidelines is described in the section 'Emissions factors' above.

e) Category-specific Recalculations

Since the emission factors with nitrification inhibitor were developed, the emissions from FY1996 to FY2013 were revised. In addition, since the activity data were updated, the emissions in FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no improvement plans.

5.5.1.2. Organic Fertilizer (3.D.a.2.)

a) Category Description

This section provides the estimation methods for N_2O emissions by application of organic fertilizer (livestock and other composting and barnyard manure).

b) Methodological Issues

- ***Estimation Method***

Emissions of N_2O have been calculated by Tier2 method in accordance with decision tree of the *2006 IPCC Guidelines* (Vol.4, p.11.9, Fig.11.2).

$$E = \sum_i (N_{ONi} \times EF_{1i}) \times 44/28$$

E : N_2O emissions from the application of organic fertilizers to agricultural soils [kg-N_2O]
N_{ONi} : Nitrogen amount of organic fertilizer applied to agricultural soil for crop type *i* [kg-N]
EF_{1i} : Emission factor for crop type *i* [kg-N_2O-N/kg-N]

- ***Emission Factors***

The same country specific emission factor used for synthetic fertilizer is used. (Table 5-41)

- ***Activity Data***

For activity data (total amount of nitrogen contained in the organic fertilizers), the following nitrogen was calculated on the basis of formula described in the *2006 IPCC Guidelines* (Vol.4, p11.12, Equation 11.3).

$$N_{ON} = N_{AM} + N_{SEW} + N_{FU} + N_{COMPsub} + N_{OOA}$$

N_{ON} : Nitrogen amount in organic fertilizers applied to soil
N_{AM} : Nitrogen amount in livestock manure applied to soil
N_{SEW} : Nitrogen amount in sewage sludge applied to soil
N_{FU} : Nitrogen amount in human waste applied to soil
$N_{COMPsub}$: Nitrogen amount in composting sub-material applied to soil (rice straw, rice husk ,wheat straw)
N_{OOA} : Nitrogen amount in other organic fertilizers applied to soil (fish residue, soybean oil residue, canola oil residue, etc.)

➢ *Nitrogen amount in livestock manure applied to soil (N_{AM})*

Amount of nitrogen in livestock manure applied to agricultural soil (N_{AM}) was calculated by subtracting the amount of nitrogen included in grazing cattle manure (N_{PRP}), nitrogen in livestock manure volatilized as N_2O (excluding grazing cattle) (N_{N2O}), nitrogen in manure volatilized as NH_3 and NO_X (excluding grazing cattle) ($N_{NH3+NOx}$), nitrogen eliminated by "incineration" and "purification" ($N_{inc+pur}$), and nitrogen in manure disposed directly as waste ($N_{disposal}$) from the total nitrogen in livestock manure ($N_{Total-AW}$).

$$N_{AM} = N_{Total\text{-}AW} - N_{PRP} - N_{N2O} - N_{NH3+NOx} - N_{inc+pur} - N_{disposal}$$

N_{AM}	: Nitrogen amount in livestock manure applied to soil [kg-N]
$N_{Total-AW}$	:Total amount of nitrogen excreted by livestock [kg-N]
N_{PRP}	:Amount of nitrogen included in grazing cattle manure [kg-N]
N_{N2O}	:Nitrogen in livestock manure volatilized as N_2O(excluding grazing cattle) [kg-N]
$N_{NH3+NOx}$	:Nitrogen in manure volatilized as NH_3 and NO_X (excluding grazing cattle) [kg-NH_3-N + NO_X-N]
$N_{inc+pur}$	:Nitrogen eliminated by "incineration" and "purification [kg-N]
$N_{disposal}$	:Amount of nitrogen in manure disposed directly as waste [kg-N]

For the amount of nitrogen included in grazing livestock manure (N_{PRP}), nitrogen in livestock manure volatilized as N_2O (excluding grazing livestock) (N_{N2O}) and nitrogen eliminated by "Incineration" and "Purification ($N_{inc+pur}$), the amount calculated in 3.B. Manure management were used.

Nitrogen in manure disposed directly as waste ($N_{disposal}$) includes manure sent to landfill after treatment ("Treated disposal") and manure sent directly to landfill without treatment ("Direct final disposal"). The amount of treated disposal manure is negligible and its treatment method is unknown. Therefore, treated disposal manure was included in the calculation of the direct final disposal manure.

The amount of nitrogen in manure disposed directly as waste ($N_{disposal}$) was calculated as equation below. For the total amounts of direct final disposal and treated disposal, data shown in the *Report on the Survey for Research on the Wide-range Movement of Wastes and the State of Cyclical Use of Wastes* were used. Average nitrogen contents in manure were calculated from total nitrogen amount in manure and total manure amount.

The livestock manure that was not applied to agricultural soils but disposed directly was included in the estimation of "7.2.1. Emissions from Managed Landfill Sites (5.A.1.)"

Nitrogen content in livestock manure disposed in the direct final disposal ($N_{disposal}$)
= Total amount of direct final disposal and treated final disposal × Average nitrogen contents in manure

Table 5-47 Nitrogen amount in livestock manure applied to agricultural soil (N_{AM}) [t-N]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total nitrogen amount in animal manure ($N_{Total-AW}$)	808,157	766,166	724,712	699,380	707,956	706,543	705,561	705,648	700,161	703,077	696,906	692,425	685,867
Nigrtogen amount in manure for grazing animal (N_{PRP})	14,145	13,829	12,697	11,868	11,735	11,740	11,668	11,802	11,591	11,497	11,299	11,092	10,961
Amount of N_2O-N released from manure (excluing Incineration and Purification) (N_{N2O})	4,752	4,637	4,534	5,077	5,256	5,424	5,560	5,674	5,554	5,538	5,436	5,343	5,251
Amount of NH_3-N and NOx-N released from manure (excluding garazing animal) (N_{NH3}+N_{Nox})	272,463	258,375	242,564	224,986	227,520	224,625	221,675	220,293	219,887	221,246	219,880	219,932	218,704
Nitrogen eliminated by Incineration and purification ($N_{inc+pur}$)	69,165	60,416	61,891	79,768	84,878	88,353	94,079	99,447	100,711	102,536	103,639	103,867	103,829
Nitrogen amount in manure disposed directly as waste ($N_{disposal}$)	330	316	292	282	285	284	295	377	284	293	345	357	359
Nitrogen amount in livestock manure applied to agricultural soil (N_{AM})	447,302	428,593	402,734	377,399	378,283	376,117	372,284	368,056	362,134	361,967	356,308	351,833	346,762

- ***Nitrogen amount in sewage sludge, other organic fertilizers and human wastes applied to soil (N_{SEW}, N_{OOA}, N_{FU})***

Nitrogen amount in sewage sludge and other organic fertilizers (fish residue, soybean oil residue, canola oil residue, and etc.) applied to soil (N_{SEW} and N_{OOA}) was calculated by multiplying amount of sludge and other organic fertilizer described in the *"Yearbook of Fertilizer Statistics (Pocket Edition)"* by nitrogen contents established using data provided in the *"Yearbook of Fertilizer Statistics (Pocket Edition)"* or Japan Sewage Works Association.

Nitrogen amount of human waste (N_{FU}) was calculated from the amount of human waste-derived nitrogen calculated with the data of "Waste Treatment in Japan".

Table 5-48 Amount of sludge and other organic fertilizer [kt]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Animal derived Fertilizers	384.1	389.4	341.0	262.7	223.5	287.4	291.9	227.9	268.3	267.4	302.6	380.4	380.4
Fish residue	111.5	88.6	89.0	73.9	78.4	152.6	81.6	70.0	62.2	52.1	55.4	59.9	59.9
Bone meal	113.1	134.2	112.8	11.4	10.6	14.5	20.6	20.9	16.7	20.8	19.4	15.0	15.0
Other animal derived	159.5	166.6	139.2	177.5	134.5	120.3	189.7	136.9	189.4	194.5	227.7	305.5	305.5
Plant derived fertilizers	635.9	725.7	982.4	494.8	827.8	1,639.8	972.1	554.8	1,059.5	1,310.0	1,079.7	1,043.6	1,043.6
Soybean oil residue	3.5	4.7	28.9	1.1	37.2	39.7	41.0	36.1	209.5	138.5	134.4	167.7	167.7
Canola oil residue	451.0	437.2	620.7	241.0	350.0	434.4	299.9	228.0	221.4	396.3	347.9	288.4	288.4
Other plant derived	181.4	283.8	332.8	252.7	440.7	1,165.8	631.2	290.7	628.7	775.2	597.4	587.4	587.4
Sludge	787.3	935.2	817.7	1,287.4	1,328.4	1,370.5	1,377.1	1,296.6	1,395.6	1,361.5	1,329.3	1,355.5	1,355.5

Reference: *Yearbook of Fertilizer Statistics (Pocket Edition)* (References 13)

Table 5-49 Nitrogen content rate of each organic fertilizer

Organic fertilizer	Nitrogen content
Fish residue	8.0%
Bone meal	4.1%
Other animal matter	7.5%
Soybean oil residue	7.5%
Canola oil residue	5.1%
Other vegetable matter	4.6%
Sludge	2.7%

Reference: Other than sludge: *Yearbook of Fertilizer Statistics (Pocket Edition)* (References 13),
Sludge: Established from Japan Sewage Works Association data

- ***Nitrogen amount in composting sub-material applied to soil ($N_{COMPsub}$)***

For composting sub-material, data of "composting" and "barn bedding" of rice straw, rice chaff and

wheat straw calculated from each prefecture data were used. For nitrogen content rate of rice straw, rice chaff and wheat straw, values described in 5.5.1.4. "Crop Residue" below were used (Table 5-55).

Table 5-50 Nitrogen amount in organic fertilizers applied to agricultural soil [t-N]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
From livestock manure (N_{AM})	447,302	428,593	402,734	377,399	378,283	376,117	372,284	368,056	362,134	361,967	356,308	351,833	346,762
From sewage sludge (N_{SEW})	21,257	25,250	22,078	34,760	35,867	37,003	37,183	35,007	37,682	36,759	35,892	36,599	36,599
From human waste (N_{FU})	10,394	4,747	2,116	874	729	609	1,702	457	427	369	351	286	273
From composting sub-material ($N_{COMPsub}$)	18,316	15,514	11,485	11,217	11,040	10,674	9,927	9,270	8,864	8,443	8,803	8,879	8,894
From other organic fertilizers (N_{OOA})	57,128	60,790	71,314	43,685	57,704	100,582	69,006	44,438	75,785	85,859	77,617	82,631	82,631
Total (Nitrogen amount applied to agricultural soil as organic N fertilizer) (N_{ON})	554,397	534,894	509,727	467,935	483,623	524,986	490,102	457,228	484,893	493,397	478,971	480,227	475,159

➢ ***Estimation for nitrogen amount of organic fertilizer applied to agricultural soil for crop type i***

To disaggregate the total nitrogen amount of organic fertilizers above (N_{ON}) by each crop type, ratio of nitrogen amount applied each crop type was calculated by multiplying the area of cultivation for each type of crop, by the amount of nitrogen applied per unit area for each type of crop. For nitrogen amount of fertilizer applied per unit area for tea, because of regulations and other factors, fertilizer application amounts change from year to year, same as the synthetic fertilizers. The amounts of nitrogen applied to tea fields (the total of synthetic and organic) in 1993, 1998, and 2002 investigated and summarized by Nonaka (2005) (Reference 39) and the ratio of synthetic fertilizer and organic fertilizer applied to tea according to the 2000 study (Reference 28) were used to estimate the amounts of synthetic and organic fertilizer applied. Time-series data were prepared by interpolating from 1993 to 2002, using the 1993 data for previous years, and using the 2002 data for subsequent years (see Table 5-45). Area of cultivated land by type of crop is same as synthetic fertilizers.

$$N_{ONi} = N_{ON} \times \frac{(RA_i \times RF_i / 10)}{\sum (RA_n \times RF_n / 10)}$$

N_{ONi} : Nitrogen amount of organic fertilizer applied to agricultural soil for crop type *i* [t-N]
N_{ON} : Total nitrogen amount in organic fertilizers applied to agricultural soil [t-N]
RA_i : Area of crop field for crop type *i* [t-N]
RF_i : Nitrogen amount of organic fertilizer per area of crop field for crop type *i* [kg-N/10a]
RA_n : Area of crop field by each crop type [t-N]
RF_n : Nitrogen amount of organic fertilizer per area of crop field by each crop type [kg-N/10a]

Table 5-51 Amount of nitrogen as organic fertilizers application per area by each type of crop (excluding tea)

Type of crop	Amount of application [kg-N/10a]
Vegetables	23.62
Paddy rice *	3.2
Fruit	10.90
Potatoes	7.94
Pulse	6.24
Feed crops	10.00
Sweet potato	8.85
Wheat	5.70
Coarse cereal (including Buckwheat)	1.81
Mulberries	0.00
Industrial crops	3.96
Tobacco	11.41

*The value of paddy rice was substituted for upland rice.

Source: *Research Report on Methodologies for Quantification of GHG Emission Reduction in FY 2000* (Reference 22)

Table 5-52 Amount of nitrogen as organic fertilizers application per area for tea [kg-N/10a]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Amount of organic fertilizers application per area (tea)	20.77	19.92	17.44	16.24	16.24	16.24	16.24	16.24	16.24	16.24	16.24	16.24	16.24

Source: Total amount of synthetic and organic fertilizers : Nonaka (2005) (Referenace 39)

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the emission factors, uncertainty (31%) described in the reference of EFs, Akiyama et al. (2006), was applied. For activity data for livestock manure, 9% for population of broiler given in the *Livestock Statistics* was applied as substitution. For activity data for others, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 32%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since nitrogen amount in livestock manure applied to agricultural soil, and activity data for sludge and other organic fertilizer were updated, the emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

The same emission factor has been used for inorganic and organic fertilizers. Thus, the possibility to establish separate emission factors for these two types of fertilizer is under consideration.

5.5.1.3. Urine and dung deposited by grazing animals (3.D.a.3.)

a) Category Description

This section provides the estimation methods for N_2O emissions from urine and dung deposited by grazing animals.

b) Methodological Issues

The method for calculating CH_4 and N_2O emissions from urine and dung deposited by grazing animals is described in 5.3.1 “Livestock Waste Management: Cattle, Swine and Poultry (Hen and Broiler) (3.B.1., 3.B.3., 3.B.4.)” and 5.3.2. “Buffalo, Sheep, Goats, Horses, Rabbit and Mink (3.B.2., 3.B.4.)”. N_2O emissions are counted in 3.D.a.3.

5.5.1.4. Crop Residues (3.D.a.4.)

a) Category Description

This section provides the estimation methods for N_2O emissions by crop residue plowed into soil.

b) Methodological Issues

- ***Estimation Method***

Basically, the N_2O emissions were calculated by using the *2006 IPCC Guidelines*. For Emission factors, default EF described in the *2006 IPCC Guidelines* were used. However, activity data for some crops (rice, tea, vegetables, sugarcane and sugarbeet) were estimated by country-specific method which is considered to be capable for estimating emissions more accurately than the method provided in the *2006 IPCC Guidelines*.

$$E = EF \times A \times 44/28$$

E : N_2O emissions for crop residue [kg-N_2O]
EF : N_2O EF for crop residue [kg-N_2O-N/kg-N]
A : Nitrogen amount plowed into soils as crop residue [kg-N]

- ***Emission Factors***

0.01 [kg-N_2O-N/kg-N] (Default, *2006 IPCC Guidelines*)

- ***Activity Data***

➢ ***Feed and green manure crops, wheat, barley, orts, rye, maize, pulse, tubers and roots (e.g. potato, sweetpotato), and other crops (e.g. buckwheat, tobacco)***

Activity data were calculated by the method shown in the following equation in accordance with the *2006 IPCC Guidelines*. For parameters, values in Table 5-54 and Table 5-55 were used. The proportion removed from field and burned in field for wheat, barley, rye and oats were determined on the basis of data of crop area by treating method for wheat straw surveyed by MAFF as shown in the Table 5-56. Since the survey data are not available in and before FY2006, the values for FY2007 were applied to these years. Fraction renewed of field ($Frac_{Renew}$) was determined for feed crops as 3% by expert judgment, taking into account variable survey results. For other crops, it was calculated as 100% renewed.

$$A = \sum_T \left\{ \begin{array}{c} \left(Area_{(T)} - Areaburnt_{(T)} \times CF\right) \times Frac_{Renew(T)} \times \\ \left[AG_{DM(T)} \times N_{AG(T)} \times \left(1 - Frac_{Remove(T)}\right) + \left(AG_{DM(T)} \times 1000 + Crop_{(T)}\right) \times R_{BG-BIO(T)} \times N_{BG(T)}\right] \end{array} \right\}$$

$$Area_{burnt(T)} = Area_{(T)} \times Frac_{burnt(T)}$$

A : Nitrogen amount plowed into soils as crop residue [tN]
$Area_{(T)}$: Crop area of crop T [ha]
$Area_{burnt(T)}$: Crop area burnt of crop T [ha]
CF : Combustion factor
$Frac_{Renew(T)}$: Fraction renewed of field of crop T [%]
$AG_{DM(T)}$: Dry matter of above-ground residues of crop T [Mg/ha]
$N_{AG(T)}$: N contents of above-ground residues of crop T [%]
$Frac_{Remove(T)}$: Fraction removed from field of crop T [%]
$Crop_{(T)}$: Dry matter in production of crop T [kg/ha]
$R_{BG-BIO(T)}$: Ratio of below-ground residues to above-ground biomass of crop T

$N_{BG(T)}$: N contents of below-ground residues of crop T [%]

$Frac_{burnt(T)}$: Fraction burnt on field of crop T [%]

- ***Rice***

For the amount of rice crop residue of above-ground biomass plowed into soil, the data for rice straw and rice chaff calculated from each prefecture data was used. The nitrogen content of this crop was calculated by multiplying the aforementioned data by nitrogen content in crop residue (kg-N/t) calculated from Date (1988). In addition, below-ground were calculated from production, dry matter fraction of harvested product, ratio of below-ground residues to production, N content of below-ground residues. For the ratio of below-ground residues to production ($Frac_{BGR-P}$), 27% indicated by Ogawa K. et al. (1988) (Reference 59) was used. For dry matter fraction of harvested product (DRY), 0.89 of default value indicated in the *2006 IPCC Guidelines* was used.

$$A_{Rice} = Residue \times N_{AG} + P \times DRY \times Frac_{BGR-P} \times N_{BG}$$

A_{Rice} : Nitrogen amount plowed into soils as crop residue [tN] (Rice)

Residue : Amount plowed into soils as crop residue (rice straw and chaff) [t]

N_{AG} : N contents of above-ground residues [kg-N/kg]

P : Production amount of rice [t]

DRY : Dry matter fraction of harvested product

$Frac_{BGR-P}$: Ratio of below-ground residues to production of crop T [%]

N_{BG} : N contents of below-ground residues [kg-N/kg]

- ***Tea***

For tea, "Leaf fall" and "Autumn pruning" were targeted as the residues which return into soils annually. In addition, as residues return into soil once in several years, "Medium pruning", which prunes the part of 30-50 cm from the ground and carried out once in about five years, was targeted. For the "Medium pruning", it assumed that it carried out by one fifth in every year in all area of tea field, and all of tea field will be renewal in five years. The residues' nitrogen contents were calculated by multiplying by nitrogen contents per unit area of "Leaf fall", "Autumn pruning" and "Medium pruning" by crop field areas. The crop field areas used for this were the data indicated in the *Statistics of Cultivated and Planted Area* by MAFF.

$$A_{Tea} = (A_{AP} + A_{LF} + A_{MP}/5) \times 10 \times Area$$

A_{Tea} : Nitrogen amount plowed into soils as crop residue [kg-N] (Tea)

A_{AP} : Nitrogen amount included in residue by autumn pruning [kg-N/10a]

A_{LF} : Nitrogen amount included in residue by leaf fall [kg-N/10a]

A_{MP} : Nitrogen amount included in the residue by medium pruning [kg-N/10a]

Area : Cultivated area of tea [ha]

Table 5-53 Amount of nitrogen content included in tea residue of branch pruning

Kind of branch pruning		Amount of Nitrogen content [kg-N/10a]	Reference
Autumn pruning	Annual	7.7	Hoshina et al.(1982) (Reference 44), Kinoshita et al. (2005) (Reference 46), Tachibana et al. (1996) (Reference 47)
Medium pruning	Once in five years	19.4	Ohta et al. (1996) (Reference 48)
Leaf fall	Annual	11.5	Hoshina et al.(1982) (Reference 45)

- ***Vegetables, sugarcane and sugarbeet***

The amount of nitrogen in each crop residue plowed into soil were calculated by multiplying nitrogen content in residue per crop production calculated from Matsumoto (2000) by annual crop production (by MAFF, *Statistics of Cultivated and Planted Area* or *Vegetable Production and Shipment Statistics*) by the fraction of above-ground residue removed and fraction burnt on field (after consideration of Combustion Factor).

For the amount of nitrogen in crop residue plowed into soil, the data of the *Document of Kagoshima prefectural Institute for Agricultural Development* was used for sugarcane, and the data of *Hokkaido Fertiliser Recommendations 2010* was used for sugar beets, potato, Japanese radish and onion, and the data of Owa (1996) was used for Chinese cabbage and lettuce.

When any crop has no available data with respect to nitrogen content included in crop residue per crop production, the value for a similar type of crop was used. The same values were adopted for all fiscal years.

$$A_{Vegetable} = P \times (1 - Frac_{Remove} - Frac_{burnt} \times CF) \times N_R$$

$A_{Vegetable}$: Nitrogen amount plowed into soils as crop residue (Vegetables, Sugarcane, Sugarbeet) [tN]

P : Production amount [t]

$Frac_{Remove}$: Fraction of above-ground residue removed [%]

$Frac_{burnt}$: Fraction burnt on field [%]

CF : Combustion factor

N_R : Nitrogen contents in crop residue [kg-N/kg]

Table 5-54 Fraction of above-ground residue removed ($Frac_{Remove}$), Fraction burnt on field ($Frac_{burnt}$), Combustion factor (CF), and Ratio of below-ground residues to above-ground biomass (R_{BG-BIO})) for main crops

Crop type	Fraction of above-ground residue removed ($Frac_{Remove}$)	Fraction burnt on field ($Frac_{burnt}$)	Combustion factor (CF)	Raito of above-ground residues (R_{BG-BIO})
Vegetables	47%	7%	0.80*4	-
Sugarbeet	47% *1	7% *1	0.80*4	-
Sugarcane	47% *1	7% *1	0.80*4	-
Green manure crops	0% *2	0% *2	-	Non-legume hay:0.80 Sorghum: 0.24 *9
Feed crops	100% *3	0% *3	-	
Wheat, barley, rye and oats	Table 5-56	Table 5-56	0.90 *5	Wheat: 0.24 Barley: 0.22 Rye: 0.25 *10 Oats: 0.25
Pulse	13%	12%	0.80*4	0.19 *6
Maize, tubers and roots, other crops	47% *1	7% *1	0.80 *4	Maize: 0.22 Tubers and roots: 0.20 *7 Other crops: 0.22 *8

(Referenece) $Frac_{Remove(T)}$, $Frac_{burnt(T)}$: Research Council on Soil Function for Global Warming Countermeasures, *"Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration"* (Referenece 44)

CF, $R_{BG-BIO(T)}$: *2006 IPCC Guidelines*

*1: Value of vegetables, *2: all residue are plowed into soil, *3: all above-ground biomass removed as for feed, *4: Value of maize and/or sugarcane、*5: Value of wheat, *6: Value of Soybean, *7: Value of potato, *8: Value of grains, *9: Average value between maize and oats, *10: Substituted by oats

Table 5-55 N contents of above- and below-ground residues (N_{AG}, N_{BG}) for main crops

Crop type	N contents of above-ground residues (N_{AG})	N contents of below-ground residues (N_{BG})	Note
Rice (above ground)	Straw: 0.541% [e] Chaff: 0.423% [e]	-	Wet weight
Rice (below ground)	-	0.9% [z *3]	Dry weight
Vegetables	Japanese radish: 0.093% [b,d] Chinese cabbage: 0.071% [d] Cabbage: 0.183% [a] Lettuce: 0.164% [d] Onion: 0.019% [b,d]		Wet weight
Sugarbeet	0.095% [b,d]		
Sugarcane	0.548% [c]		Dry weight
Green manure crops and Feed crops	Non-legume hay: 1.5% [z] Sorghum: 0.7% [z]	Non-legume hay:1.2% [z] Sorghum: 0.6% [z]	
Wheat	0.43% [a]	0.9% [z]	
Barley	Two-row: 2.14% [a] Six-row: 0.31% [a]	1.4% [z]	
Rye	0.50% [z]	1.1% [z]	
Oats	0.70% [z]	0.8% [z]	
Maize	1.64% [a]	0.7% [z]	
Soybean	0.65% [a]	0.8% [z]	
Adzuki beans	0.84% [a]	1.0% [z *1]	
Potatoes	2.42% [a]	1.4% [z *2]	

<Reference>

a: Matsumoto N., *Development of Estimation Method and Evaluation of Nitrogen Flow in Regional Areas* (2000) (Reference 49)

b: Hokkaido Government, *Hokkaido Fertiliser Recommendations 2010.* (2010) (Reference 50)

c: *Document of Kagoshima prefectural Institute for Agricultural Development*

d: Owa N., *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 27)

e: Date N., *"Handbook for Organic Fertilizers and Microbial Materials"*, 1988 (Reference 53)
z: *2006 IPCC Guidelines*

*1: Substituted by dry bean

*2: Substituted by potato

*3: Substituted by wheat

Table 5-56 Proportion removed from field and burned in field for wheat, barley, rye and oats [%]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Proportion removed from field	32.1	32.1	32.1	32.1	32.1	32.1	34.0	35.9	37.8	39.8	40.2	41.0	41.0
Proportion burned in field	13.5	13.5	13.5	13.5	13.5	13.5	12.5	11.6	10.6	9.5	9.2	8.8	8.3

*Calculated from each prefecture data

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, default values (-70% to +200%) described in the *2006 IPCC Guidelines* were applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be -70% to +200%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

At the Break Out Group on Agriculture of the Committee for GHG Emissions Estimation Method in 2012, nitrogen content for rice were checked in detail. As a result, the group decided to use data by Date (1988), which were separated into rice straw and chaff and were considered as the most appropriate to represent Japan's actual circumstances because the data are intermediate among the various regional data in Japan.

e) Category-specific Recalculations

Since the data for rice straw and rice chaff plowed into soil in FY2013 were updated, the emissions in FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

Discussion whether it will be possible to establish country-specific emission factors for Japan has been conducted.

5.5.1.5. Mineralization/Immobilization Associated with Loss/Gain of Soil Organic Matter (3.D.a.5.)

a) Category Description

This section estimates N_2O emissions by nitrogen mineralization in loss of carbon oxidized by organic

matter in mineral soil.

b) Methodological Issues

- ***Estimation Method***

When using the estimation method in the *2006 IPCC Guidelines*, amount of carbon loss in organic matter in mineral soil, which is a part of activity data, cannot be figured out. Therefore, it was calculated by country-specific method by using the cultivation area of a mineral soil, and the N_2O emission per area (background N_2O emission of agricultural land).

$$E = EF \times A \times 44/28$$

E : N_2O emissions by mineralization of nitrogen in mineral soils [kg-N_2O]
EF : N_2O emission factor by mineralization of nitrogen in mineral soils per ha [kg-N_2O-N/ha]
A : Area of plowed mineral soil [ha]

- ***Emission Factors***

N_2O emission factor of background in agricultural soils in Japan (0.65 kgN_2O-N/ha) indicated by Akiyama et al.(2006), which is the scientific paper used in 4.D.a.1. “Inorganic N Fertilizers”, was used as basis of EF, and N_2O emissions by atmospheric deposition and crop residue were subtracted from the background EF.

Nitrogen amount deposited as NH_3+NOx on agricultural soils in Japan is decided by expert judgment on the basis of domestic case studies as 10kgN/ha. For nitrogen amount plowed into soils as crop residue per area, 32kgN/ha calculated in “5.5.1.4. Crop Residues (3.D.a.4.)” above are used. 0.10kgN_2O-N/ha + 0.32kgN_2O-N/ha (emission factors are 1% of atmospheric deposition amount and 1% of crop residue) which were emitted from its deposition and crop residue plowed into soil were subtracted as double counting from background EF. Finally, 0.23 (=0.65 -0.10 -0.32) kgN_2O-N/ha was used as the corrected emission factor.

- ***Activity Data***

The area of plowed mineral soil was established by multiplying the cultivated areas of paddy fields and common upland fields, obtained from the *Statistics of Cultivated and Planted Area* (MAFF), by the percentage of organic soils (peat soil and muck soil) in paddy fields and common upland fields in Japan. Percentages of organic soils and mineral soils were used data made from Takata et al.(2009). Lands of mineral soil converted to paddy field and upland field are estimated in LULUCF sector.

Table 5-57 Percentage of organic soils and mineral soils

Type		~1991	1992	1997	2001	2002~
Paddy field	Organic soils	5.85%	**5.85%**	6.02%	**6.15%**	6.15%
	Mineral soils	94.15%	**94.15%**	93.98%	**93.85%**	93.85%
Upland field	Organic soils	1.94%	**1.94%**	2.01%	**2.07%**	2.07%
	Mineral soils	98.06%	**98.06%**	97.99%	**97.93%**	97.93%

*1992 data and 2001 data were original data. 1993-2000 data were calculated by using interpolation between 1992 and 2001. 1992 data was used for data before 1991 and 2001 data was used for data after 2002.
Source: Calculated from Takata et al.(2009) (Reference 42)

Table 5-58 Areas of organic soil and mineral soil [kha]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Area of organic soil (paddy)	163	162	161	156	156	155	154	154	154	151	151	151	151
Area of mineral soil (paddy)	2,683	2,583	2,480	2,399	2,387	2,375	2,361	2,352	2,342	2,323	2,318	2,314	2,306
Area of organic soil (upland)	25	24	24	24	24	24	24	24	24	24	24	24	24
Area of mineral soil (upland)	1,250	1,201	1,164	1,149	1,149	1,148	1,147	1,145	1,145	1,141	1,140	1,137	1,132

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For the emission factors, uncertainty (31%) described in the reference of EFs, Akiyama et al. (2006), was applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 31%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since emission factor was updated, emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

It is planned to discuss the subtraction method for double count of N_2O emissions from the EF of Akiyama et al. (2006)

5.5.1.6. Plowing of Organic Soil (3.D.a.6.)

a) Category Description

In Japan, there are organic soils in Hokkaido. Two types, “muck soil” and “peat soil”, are treated as organic soils. In Japan, the creation of farmland on organic soils was mostly completed by the 1970s, and in general farmers till land that has had soil dressing.

b) Methodological Issues

- ***Estimation Method***

Emissions of N_2O from the plowing of organic soil were calculated by multiplying the area of the plowed organic soil of paddy field, upland field, and grassland by the emission factor in accordance with the *2006 IPCC Guidelines*.

$$E = EF \times A \times 44/28$$

E : N_2O emission associated with the plowing of organic soil [kg-N_2O]

EF : N_2O emission factor for plowing of organic soil [kg-N_2O-N/ha]
A : Area of plowed organic soil [ha]

- ***Emission Factors***

For paddy cultivation in organic soils, it is known that N_2O emission in paddy field is lower than the one in upland field. In Japan, Nagata (2006) (Reference 43) observed N_2O emissions for paddy of organic soil in Hokkaido, but the observations included emissions from applied nitrogen. Therefore, country-specific emission factor is determined to be 0.30 [kg-N_2O-N/ha/year] by deducting country-specific emission factor of fertilizers indicated in Akiyama (2006). For the upland field of organic soil, some observation results exists (Nagata 2006, Nagata 2009 (Reference 46)), but there is not much difference from the default of temperate region (8 [kg-N_2O-N/ha/year]) indicated in *2006 IPCC Guidelines*. Therefore, default value is used for upland field. For grassland, same default value (8 [kg-N_2O-N/ha/year]) is used.

- ***Activity Data***

The area of plowed organic soil was used the data indicated in Table 5-58 above. Annual renewal ratio of grassland is decided as 3% by expert judgment with survey results, and annual plowed area is calculated using the value and organic soil area of grassland.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, default values (-75% to +200%) described in the *2006 IPCC Guidelines* were applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be -75% to +200%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculation

f) Category-specific Planned Improvements

No improvement plans.

5.5.2. Indirect Emissions (3.D.b.)

Nitrogen compounds such as ammonia, that volatilize and are released into the atmosphere from synthetic fertilizers applied to agricultural soils, organic fertilizers applied to agricultural soils and the grazing livestock manure applied to soil are deposited on soil as the results of various actions, including turbulent diffusion, molecular diffusion, effect of electrostatic forces, chemical reactions,

plant respiration, and being washed out of the air by rain. In this section, the amount of N_2O generated by microbe activity on the deposited nitrogen compounds was calculated.

N_2O is generated by the action of microbes on nitrogen that leaches or runs off as nitrate from synthetic fertilizers, organic fertilizers and etc.

5.5.2.1. Atmospheric Deposition (3.D.b.1.)

a) Category Description

This section provides the estimation methods for N_2O indirect emissions caused by atmospheric deposition of nitrogen compounds volatilized as NH_3 and NOx from synthetic fertilizers applied to soil, organic fertilizers applied to soil, and the grazing livestock manure applied to soil.

b) Methodological Issues

- ***Estimation Method***

N_2O emissions have been calculated in accordance with decision tree of the *2006 IPCC Guidelines* (Vol. 4, Page 11.20, Fig11.3).

$$E = EF \times A \times 44/28$$

E	: N_2O emissions from atmospheric deposition [kg N_2O]
EF	: N_2O Emission factor for atmospheric deposition [kg-N_2O-N/ kg-NH_3-N+NO_X-N volatilized]
A	: Total nitorgoen amount volatilized as NH_3 and NOx from synthetic fertilizers, organic fertilizers, and grazing livestock manure [kg-NH_3-N+NO_x-N]

- ***Emission Factors***

0.01 [kg-N_2O-N/kg-NH_3-N & NO_X-N volatilized] (default value, *2006 IPCC Guidelines*, Vol.4 Table11.3).

- ***Activity Data***

As described in the following equation, the activity data are composed of the “nitrogen amount volatilized as NH_3 and NOx from inorganic fertilizers applied to soil, organic fertilizers applied to soil, and the grazing livestock manure applied to soil. The “nitrogen amount volatilized NH_3 and NOx in process of livestock manure management” are reported in 3.B.5.

$$A = N_{FERT} \times Frac_{GASF} + N_{ON} \times Frac_{GASM3} + N_{PRP} \times Frac_{GASM4}$$

A	:Total N amount volatilized as NH_3 and NOx from synthetic fertilizers, organic fertilizers, and grazing livestock manure [kg-NH_3-N+NO_x-N]
N_{FERT}	:N amount for inorganic fertilizers applied to agricultural soil [kg-N]
$Frac_{GASF}$	:Percentage of volatilization as NH_3 and NOx from inorganic fertilizers applied to agricultural soil [(kg-NH_3-N + NO_X-N)/kg-N]
N_{ON}	:N amount for organic fertilizers applied to agricultural soil [kg-N]
$Frac_{GASM3}$	Percentage of volatilization as NH_3 and NOx from nitrogen contained in livestock manure and human waste applied to agricultural soils[(kg-NH_3-N + NO_X-N)/kg-N]
N_{PRP}	:N amount in grazing livestock manure [kg-N]
$Frac_{GASM4}$	: Fraction of volatilization as NH_3 and NOx from livestock manure during treatment [(kg-NH_3-N + NO_X-N)/kg-N]

➢ ***N amount volatilized as NH_3 and NOx from inorganic fertilizers applied to soil ($N_{FERT} \times Frac_{GASF}$)***

"N amount of synthetic fertilizer applied to agricultural soil" calculated in the Inorganic N Fertilizers (3.D.a.1.) (Table 5-42) was used for the amount of fertilized nitrogen (N_{FERT}), and the default value, indicated in Table 5-59, given in the *2006 IPCC Guidelines* was used for the percentage of volatilization ($Frac_{GASF}$).

Table 5-59 Proportion of nitrogen volatilized from synthetic fertilizers and organic fertilizers as ammonia or nitrogen oxides

	Value	Unit
$Frac_{GASF}$	0.10	[kg-NH_3-N + NO_X-N/kg of synthetic fertilizer nitrogen applied]
$Frac_{GASM}$	0.20	[kg-NH_3-N + NO_X-N/kg of nitrogen excreted by livestock]

Source: *2006 IPCC Guidelines* Vol. 4, Table 11.3

➢ ***N amount volatilized as NH_3 and NOx from organic fertilizers applied to agricultural soil ($N_{ON} \times Frac_{GASM3}$)***

For nitrogen amount in organic fertilizers applied to agricultural soil (N_{ON}), the data described in the "Organic N Fertilizers (4.D.a.2.)" were used. For proportion of nitrogen volatilized as NH_3 and NOx ($Frac_{GASM3}$), default value ($Frac_{GASM}$＝0.20) of the *2006 IPCC Guidelines* indicated in Table 5-59 above was used.

➢ ***N amount volatilized as NH_3 and NOx from grazing livestock manure ($N_{PRP} \times Frac_{GASM4}$)***

For the nitrogen amount in grazing livestock manure (N_{PRP}), the calculated data in 3.B. were used. For proportion of nitrogen volatilized as NH_3 and NOx ($Frac_{GASM4}$), default value ($Frac_{GASM}$＝0.20) of the *2006 IPCC Guidelines* indicated in Table 5-59 was used.

Table 5-60 Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers, livestock manure, and human waste [t(NH_3-N+NOx-N)]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
From inorganic N fertilizers applied to soil ($N_{FERT} \times Frac_{GASF}$)	61,167	52,727	48,718	47,097	45,354	47,882	35,990	34,997	40,940	38,702	39,660	40,973	40,973
From organaic N fertilizers ($N_{ON} \times Frac_{GASM3}$)	110,879	106,979	101,945	93,587	96,725	104,997	98,020	91,446	96,979	98,679	95,794	96,045	95,032
From grazing livestock manure ($N_{PRP} \times Frac_{GASM4}$)	2,829	2,766	2,539	2,374	2,347	2,348	2,334	2,360	2,318	2,299	2,260	2,218	2,192
Total (nitrogen amount volatilized as ammonia and nitrogen oxides (A)	174,875	162,471	153,202	143,058	144,425	155,227	136,344	128,803	140,237	139,681	137,714	139,236	138,197

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, uncertainty (-106% to +447%) was calculated by synthesis of defaults of each parameter described in the *2006 IPCC Guidelines*. For activity data, 9% for population of broiler given in the *Livestock Statistics* was applied as substitution. As a result, the uncertainties of the emissions were determined to be -106% to +447%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since each nitrogen amount for inorganic fertilizers, organic fertilizers, and grazing livestock manure was updated, the emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

Discussion for the establishment of country-specific emission factors and the ratios of volatile nitrogen compounds has been conducted.

5.5.2.2. Nitrogen Leaching and Run-off (3.D.b.2.)

a) Category Description

This section provides the estimation methods for N_2O emissions from Nitrogen Leaching and Run-off.

b) Methodological Issues

- ***Estimation Method***

N_2O emissions were calculated according to the decision tree in the *2006 IPCC Guidelines* (Vol. 4, Page 11.20, Fig11.3), by multiplying default emission factors by the amount of nitrogen that leached and run-off.

$$E = EF \times A \times 44/28$$

E : N_2O emissions from N leaching and run-off [kg N_2O]

EF : N_2O Emission factor for N leaching and run-off [kg-N_2O-N/kg-N]

A : Total nitrogen amount for N leaching and run-off from synthetic fertilizers, organic fertilizers, and etc. [kg-N]

- ***Emission Factors***

0.0075 [kg-N_2O-N/kg-N] (default value, *2006 IPCC Guidelines*).

- ***Activity Data***

As described the formula below, activity data was composed of each nitrogen amount of leaching and run-off by synthetic fertilizers, organic fertilizers, grazing livestock manure, crop residue, and carbon loss by mineralization. Each AD was calculated by multiplying the default value of proportion of leaching and run-off given in the *2006 IPCC Guidelines* (0.30 [kg-N/kg-N]) by the amount of nitrogen calculated in 3.D.a.1. to 3.D.a.5. above.

$$A = (N_{FERT} + N_{ON} + N_{PRP} + N_{CR} + N_{SOM}) \times Frac_{LEACH}$$

A	: Total nitrogen amount for N leaching and run-off from inorganic fertilizers, organic fertilizers, and etc. [kg-N]
N_{FERT}	: Nitrogen amount in inorganic fertilizers applied to agricultural soil [kg-N]
N_{ON}	: Nitrogen amount in organic fertilizers applied to agricultural soil [kg-N]
N_{PRP}	: Nitrogen amount in grazing livestock manure [kg-N]
N_{CR}	: Nitrogen amount in crop residue plowed into soil [kg-N]
N_{SOM}	: Nitrogen amount in mineralization in loss of carbon oxidized by organic matter in mineral soil [kg-N]
$Frac_{LRACH}$	: Fraction of nitrogen leaching and run-off in each activity [kg- -N/kg-N] (=0.30) (default value in the *2006 IPCC Guidelines* (Vol.4 Table11.3))

Table 5-61 Total nitrogen amount for N leaching and run-off from synthetic fertilizers, organic fertilizers, and etc. [t (NH_3-N+NO_X-N)]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
From inorganic N fertilizers applied to soil (N_{FERT}×$Frac_{LEACH}$)	183,500	158,181	146,153	141,291	136,061	143,645	107,970	104,991	122,819	116,106	118,979	122,918	122,918
From organaic N fertilizers (N_{ON}×$Frac_{LEACH}$)	166,319	160,468	152,918	140,381	145,087	157,496	147,031	137,168	145,468	148,019	143,691	144,068	142,548
From grazing livestock manure (N_{PRP} ×$Frac_{LEACH}$)	4,243	4,149	3,809	3,560	3,520	3,522	3,500	3,540	3,477	3,449	3,390	3,328	3,288
From crop residue (N_{CR}×$Frac_{LEACH}$)	45,299	44,717	47,719	43,955	41,848	42,163	41,525	38,834	37,750	37,521	38,290	38,276	38,469
From mineralization (N_{SOM}×$Frac_{LEACH}$)	71,537	69,174	67,024	65,428	65,240	65,043	64,820	64,648	64,497	64,045	63,949	63,830	63,608
Total (nitrogen amount by leaching and run-off) (A)	470,899	436,689	417,623	394,615	391,756	411,870	364,846	349,183	374,012	369,140	368,299	372,419	370,830

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, uncertainty (-115% to +287%) was calculated by synthesis of defaults of each parameter described in the *2006 IPCC Guidelines*. For activity data, 9% was applied as same as “Atmospheric Deposition” above. As a result, the uncertainties of the emissions were determined to be -115% to +287%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since each nitrogen amount for inorganic fertilizers, organic fertilizers, grazing livestock manure, crop residue, and mineralization was updated, the emissions for all years were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

Discussion for the establishment of country-specific emission factors and the fraction of nitrogen leaching and run-off has been conducted.

5.6. Prescribed Burning of Savannas (3.E.)

This source is given in the *2006 IPCC Guidelines* as "being for the purpose of managing pastureland in sub-tropical zones". There is no equivalent activity in Japan, and this source has been reported as "NO".

5.7. Field Burning of Agricultural Residues (3.F.)

a) Category Description

Incomplete burning of crop residues in field releases CH_4 and N_2O into the atmosphere. CH_4 and N_2O emissions from this source are calculated and reported in this category.

CH_4 and N_2O emissions from Field Burning of Agricultural Residues in FY2014 are 72 kt-CO_2 eq. and 22 kt-CO_2 eq., comprising 0.005% and 0.002% of total emissions (excluding LULUCF), respectively. The value represents a reduction by 43.5% and 43.5% for CH_4 and N_2O from FY1990, respectively.

Table 5-62 CH_4 and N_2O emissions from field burning of agriculture residues

Gas	Item		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	3.F.1. Cereals	Wheet	kt-CH_4	0.38	0.22	0.27	0.31	0.32	0.31	0.28	0.26	0.24	0.22	0.21	0.20	0.19
		Barley	kt-CH_4	0.15	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.06	0.06	0.06	0.05
		Maize	kt-CH_4	0.08	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
		Rice	kt-CH_4	1.96	2.05	1.38	1.03	0.94	0.87	0.76	0.71	0.70	0.70	0.66	0.75	0.75
		Other cereals	kt-CH_4	0.06	0.05	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.11	0.12	0.12	0.12
	3.F.2. Pulses	Soybeans	kt-CH_4	0.47	0.22	0.40	0.43	0.46	0.45	0.48	0.47	0.45	0.44	0.42	0.42	0.43
		Other pulses	kt-CH_4	0.35	0.27	0.22	0.19	0.16	0.17	0.17	0.16	0.16	0.16	0.15	0.16	0.16
	3.F.3. Tubers and roots	Potatoes	kt-CH_4	0.23	0.20	0.18	0.17	0.17	0.17	0.17	0.16	0.16	0.16	0.16	0.16	0.15
		Sugarbeet	kt-CH_4	0.14	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.11	0.11
		Other tubers and roots	kt-CH_4	0.20	0.17	0.15	0.13	0.13	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.12
	3.F.4. Sugarcane		kt-CH_4	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
	3.F.5. Other	Vegetables	kt-CH_4	0.95	0.87	0.81	0.74	0.73	0.72	0.72	0.72	0.72	0.71	0.71	0.70	0.69
		Other crops	kt-CH_4	0.08	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.02	0.02	0.02
	Total		kt-CH_4	5.1	4.4	3.8	3.4	3.3	3.2	3.1	3.0	2.9	2.9	2.8	2.9	2.9
			kt-CO_2eq	127	111	96	86	83	81	78	76	74	73	71	72	72
CH_4	3.F.1. Cereals	Wheet	kt-N_2O	0.010	0.006	0.007	0.008	0.008	0.008	0.007	0.007	0.006	0.006	0.005	0.005	0.005
		Barley	kt-N_2O	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001
		Maize	kt-N_2O	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Rice	kt-N_2O	0.051	0.053	0.036	0.027	0.024	0.023	0.020	0.018	0.018	0.018	0.017	0.019	0.019
		Other cereals	kt-N_2O	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003
	3.F.2. Pulses	Soybeans	kt-N_2O	0.012	0.006	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.011	0.011	0.011	0.011
		Other pulses	kt-N_2O	0.009	0.007	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	3.F.3. Tubers and roots	Potatoes	kt-N_2O	0.006	0.005	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
		Sugarbeat	kt-N_2O	0.004	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
		Other tubers and roots	kt-N_2O	0.005	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	3.F.4. Sugarcane		kt-N_2O	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	3.F.5. Other	Vegetables	kt-N_2O	0.025	0.023	0.021	0.019	0.019	0.019	0.019	0.019	0.019	0.018	0.018	0.018	0.018
		Other crops	kt-N_2O	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Total		kt-N_2O	0.13	0.12	0.10	0.09	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07
			kt-CO_2eq	39	34	30	26	26	25	24	23	23	22	22	22	22
Total of all gases			kt-CO_2eq	166	145	126	112	109	106	102	99	96	95	93	94	94

b) Methodological Issues

- ***Estimation Method***

CH_4 and N_2O emissions were calculated by using the method indicated in the *2006 IPCC Guidelines.*

$$E=A\times M_B\times C_f\times G_{ef}\times 10^{-3}$$

E	: CH_4 and N_2O emissions from field burning of agriculture residues [tCH_4 or tN_2O]
A	: Area burnt [ha]
M_B	: mass of fuel available for combustion [t/ha]
C_f	: Combustion factor
G_{ef}	: emission factor [gCH_4/kg or gN_2O/kg]

- ***Emission Factors***

CH_4: 2.7 g-CH_4/kg (dry matter) (default value in the *2006 IPCC Guidelines*)
N_2O: 0.07 g-N_2O/kg (dry matter) (default value in the *2006 IPCC Guidelines*)

- ***Activity Data***

Parameters used in estimation are indicated in the Table 5-63 below. For proportion of burned residue and combustion factor, same values to estimate N_2O emissions for crop residue were used. For rice, since data of burned residue in field is available, mass of fuel available for combustion (M_B) was not multiplied in estimation.

The proportion burned in field for wheat, barley, rye and oats were determined on the basis of data of crop area by treating method for wheat straw calculated from each prefecture data as shown in Table 5-56 above.

Table 5-63 Proportion of burned residue on agricultural field, MB×Cf and Combustion factor

Crop	Proportion of burned residue	$M_B\times C_f$	Combustion Factor (Cf)
Rice	---	---	0.80
Pulse	12% *1	10 *3	---
Vegetable, Sugarbeet, Maize, Tuber crops (e.g. potato), Buckwheat, Canola seed, Konjac, Rush grass, Tabaco	7% *2	10 *3	---
Sugarcane	7% *2	6.5	---
Wheat, Barley, Ray, Oats	See Table X-X below	4 *4	---

Referenece: Proportion burned: Research Council on Soil Function for Global Warming Countermeasures, "Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration" (Referenece 44)

$M_B\times C_f$: *2006 IPCC Guidelines*

*1: value of pulse, *2: value of vegetable, *3: value of maize, *4: value of wheat

For rice, amount of burning rice straw and rice chaff on crop field is surveyed by MAFF (Table 5-64). For other crops, area data described in the *Crop Statistics* or the *Vegetable Production and Shipment Statistics* by MAFF are used.

Table 5-64 Amount of burning rice straw and rice chaff on crop field [kt]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Rice straw	438.2	536.9	429.1	276.6	240.8	203.6	183.9	163.5	149.3	187.0	149.4	183.4	183.4
Rice chaff	581.3	528.3	291.3	260.3	246.4	249.9	209.9	206.0	212.9	179.2	195.6	206.6	206.6
Total	1,019.5	1,065.2	720.4	536.9	487.2	453.5	393.8	369.4	362.2	366.2	345.0	390.0	390.0

Source: Calculated from each prefecture data

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, uncertainties (CH_4: 296%, N_2O: 300%) were calculated by synthesis of defaults of each parameter described in the *2006 IPCC Guidelines*. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 296% for CH_4 and 300% for N_2O.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since the amount of burning rice straw and rice chaff on crop field were updated, the emissions in FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvement plan

5.8. Liming (3.G.)

a) Source/Sink Category Description

This category deals with CO_2 emissions from agricultural lime application. CO_2 emissions from this category in FY2014 were 380 kt-CO_2, comprising 0.03 % of total emissions (excluding LULUCF). The value represents a decrease by 31.0% from FY1990.

Table 5-65 CO_2 emissions from agricultural lime application

Gas	Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	3.G.-Limestone	kt-CO_2	550	303	332	231	230	324	304	270	242	246	369	379	379
	3.G.-Dolomite	kt-CO_2	0.3	0.5	0.5	0.6	0.4	0.7	1.7	0.6	1.0	1.1	0.6	1.1	1.1
	Total	kt-CO_2	550	304	333	231	230	325	306	270	243	247	370	380	380

b) Methodological Issues

- ***Estimation Method***

The Tier 1 method is used in accordance with the decision tree described in the *2006 IPCC Guidelines* (Vol.4, 11.27, Figure11.4).

$$E = (M_{Limestone} \times EF_{Limestone} + M_{Dolomite} \times EF_{Dolomite}) \times 44/12$$

E : annual CO_2 emissions from agricultural lime application [t-CO_2/yr]
$M_{Limestone}$: annual amount of calcic limestone [t/yr]
$M_{Dolomite}$: annual amount of dolomite [t/yr]
$EF_{Limestone}$: emission factor of calcic limestone [t-C/t]
$EF_{Dolomite}$: emission factor of dolomite [t-C/t]

- ***Parameters***

➢ ***Emission factor of calcic limestone ($CaCO_3$)***

0.12 [t-C/t] (default value, *2006 IPCC Guideline*s).

➢ ***Emission factor of dolomite($CaMg(CO_3)_2$)***

0.13 [t-C/t] (default value, *2006 IPCC Guidelines*).

- ***Activity Data***

➢ ***Annual amount of lime applied to Cropland***

These data were calculated by adding up lime production and import quantities as listed in *the Yearbook of Fertilizer Statistics (Pocket Edition)* published by the Association of Agriculture and Forestry Statistics. Based on expert judgment, all of the "Calcium carbonate fertilizer" and 70% of each of "Fossil seashell fertilizer", "Crushed limestone" and "Seashell fertilizer" listed in the Yearbook were classified as calcic limestone ($CaCO_3$), and all of the "Magnesium carbonate fertilizer" and 74% of "Mixed magnesium fertilizer" as dolomite ($CaMg(CO_3)_2$).

Table 5-66 Amount of limestone and dolomite applied to agricultural soils [kt]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Applied Limestone	1,250	689	755	524	523	737	691	613	550	558	839	860	860
Applied Dolomite	0.7	1.1	1.1	1.4	0.8	1.5	3.5	1.2	2.0	2.4	1.3	2.2	2.2

Source: Estimated from the data described in "Yearbook of Fertilizer Statistics (Pocket Edition)"

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

For uncertainty of the emission factor, default values (50%) described in the *2006 IPCC Guidelines* was applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 50%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Source-/Sink-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since activity data in FY2013 were updated, the emissions in FY2013 were revised. See Chapter 10

for impact on trend.

f) Source-/Sink-specific Planned Improvements

There are no improvement plans.

5.9. Urea application (3.H.)

a) Source/Sink Category Description

CO_2 are released into the air by application of urea ($(NH_3)_2CO$) fertilizer via hydrogen carbonate ions (HCO_3^-) which is released in soil water. This category deals with estimation and reporting for this CO_2 emissions. Since estimation of urea production in Japan in Industrial Processes sector includes CO_2 emission in use phase, this category estimates CO_2 emissions from use phase of imported urea fertilizer.

CO_2 emissions from this category in FY2014 were 198 kt-CO_2, comprising 0.01 % of national total emissions (excluding LULUCF). The value represents an increase by 238 % from FY1990.

Table 5-67 CO_2 emissions from urea fertilizer

Gas	Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	3.H. Urea fertilization	kt-CO_2	59	56	110	179	153	175	134	120	160	168	150	198	198

b) Methodological Issues

- ***Estimation Method***

The Tier 1 method is used in accordance with the decision tree described in the *2006 IPCC Guidelines* (Vol.4, 11.33, Figure11.5).

$$E = (M \times EF) \times 44/12$$

E : annual CO_2 emissions from urea fertilizer [t-CO_2/yr]
M : annual amount of imported urea fertilizer [t/yr]
EF : emission factor of urea fertilizer [t-C/t]

- ***Emission Factors***

0.20 [t-C/t] (default value, *2006 IPCC Guidelines*).

- ***Activity Data***

These data were calculated by deducting "amount of domestic urea production for fertilizer" from "total demand of urea fertilizer" described in *the Yearbook of Fertilizer Statistics (Pocket Edition)* published by the Association of Agriculture and Forestry Statistics.

Table 5-68 Amount of imported urea fertilizer [kt]

Item	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Amount of imported urea fertilizer	80	76	149	244	209	239	183	164	218	229	205	270	270

Source: Estimated from the data described in "*Yearbook of Fertilizer Statistics* (Pocket Edition)"

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

For uncertainty of the emission factor, default value (50%) described in the *2006 IPCC Guidelines*

was applied. For activity data, 1% for area of paddy fields given in the *Statistics of Cultivated and Planted Area* was applied as substitution. As a result, the uncertainties of the emissions were determined to be 50%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since activity data from FY2011 to FY2013 were updated, the emissions from FY2011 to FY2013 were revised. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

There are no improvement plans.

5.10. Other carbon-containing fertilizers (3.I.)

Since there are no other sources to be reported in this category, this category is reported as “NO”.

5.11. Other (3.J.)

Since there are no other sources as “Other”, this category is reported as “NO”.

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Chapter 6. Land Use, Land-Use Change and Forestry (CRF sector 4)

6.1. Overview of Sector

The land use, land-use change, and forestry (LULUCF) sector deals with greenhouse gas (GHG) emissions and removals resulting from land use such as forestry activities and land-use change. Japan classifies its national land into six categories—forest land, cropland, grassland, wetlands, settlements, and other land—and subdivides each of them into two subcategories by distinguishing them on the basis of whether or not land conversion has been occurred, in accordance with the *2006 IPCC Guidelines*; a default value of 20 years was used when distinguishing the land conversion. GHG emissions and removals in this sector consist of carbon stock changes in five carbon pools (aboveground biomass, belowground biomass, dead wood, litter, and soil), carbon stock changes in harvested wood products (HWP) in forest land, direct N_2O emissions from N fertilization in forest land, CH_4 and N_2O emissions from drainage of organic soils, N_2O emissions from nitrogen mineralization resulting from change of land use or management of mineral soils, indirect N_2O emissions from managed soils, and non-CO_2 emissions from biomass burning. Tiers of methodology used in this sector are showed in Table 6-1. In this chapter, above- and below- ground biomass are referred to collectively as "living biomass", and dead wood and litter collectively as "dead organic matter".

Japan's total land area as of FY2014 is about 37.8 million ha, which represents an increase of 0.06% over the FY1990 value. The increase results from reclamation by drainage and soil filling of sea areas[1]. The largest portion of the national land is forest land, which covers about 25.1 million ha. The second-largest portion is cropland, which covers about 4.31 million ha. In addition, grassland, wetlands, settlements, and other land cover about 0.95 million ha, 1.34 million ha, 3.81 million ha, and 2.28 million ha, respectively. Japan includes the land territory in the LULUCF estimation and reporting and does not include sea area which the *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands* (*Wetlands Guidelines*) provides some methodologies.

Japan's national land is an archipelago consisting of Hokkaido, Honshu, Shikoku, Kyushu and other islands, and lies off the east coast of the Eurasian Continent. The archipelago has the general shape of a crescent and extends from northeast to southwest. Its northernmost point is located at about 45 degrees north latitude, and its southernmost point is located at about 20 degrees north latitude. Most of Japan's national land is located in a temperate, humid climate zone. Some islands in the southern part of Japan belong to a subtropical climate zone, and the northern part of Japan is located in a cool-temperate climate zone. The average annual temperature and precipitation in Tokyo, the capital city of Japan located in the temperate, humid climate zone, are 16.3 degrees centigrade and 1,528.8mm; those in Sapporo, Hokkaido prefecture, located in the cool-temperate climate zone, are 8.9 degrees centigrade and 1,106.5 mm; and those in Naha, Okinawa prefecture, located in the subtropical climate zone, are 23.1 degrees centigrade and 2,040.8 mm, respectively.[2]

[1] Statistical reports on the land area by prefectures and municipalities in Japan <http://www.gsi.go.jp/kokusaikoryu/kokusaikoryu-e30092.html>

[2] The average annual temperatures and precipitation are the average of the years between FY1981 and 2010. See National Astronomical Observatory, *2012 Chronological Scientific Tables* (Tokyo: Maruzen Inc., 2011) pp.182-183 and pp.194-195. With respect to the degrees of latitude, see Geographical Survey Institute, *Degrees of Latitudes and Longitudes of Japan's*

The LULUCF sector contains both sources and sinks; however, in Japan, it has been a net sink continuously since FY1990. Net removals in FY 2014 were 61,463 kt-CO_2; this accounts for 4.5% of the total national emissions (excluding LULUCF). The net removals in FY2014 also represent an increase of 3.7% over the FY1990 value and a decrease of 5.5% below the FY2013 value. The key drivers for the rise in removals since 1990 are increase of removals in forest land and decrease of emission resulting from land conversion because of decrease of areas of land conversion since 1990. Net removals in Japan have been decreased continuously since 2003 due to decrease of removals in forest land. See descriptions in each category for further information on reasons of trends.

This chapter is divided into 16 sections. Sections 6.2. and 6.3. describe the method of determining land-use categories and the method of determining areas (data base and estimation method of determining areas). Section 6.4. describes general parameters for estimating carbon stock changes from land-use conversion. Sections 6.5. to 6.10. explain the estimation methods of carbon stock changes in each land-use category. Section 6.11. describes estimation method of carbon stock changes in Harvested Wood Products (HWP). In addition, GHG emissions by the LULUCF sector resulting from other than carbon stock changes are described in sections 6.12 to 6.16.

Table 6-1 Tier of methodology used in LULUCF sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
4. Land use, land-use change and forestry	T1,T2,T3	CS,D	T1	CS,D	CS,T1,T2	CS,D
A. Forest land	T1,T2,T3	CS,D	T1	D	T1,T2	CS,D
B. Cropland	T1,T2	CS,D	T1	D	T1,CS	CS,D
C. Grassland	T1,T2	CS,D	T1	D	CS	CS
D. Wetlands	T1,T2	CS,D	NO,NA,NE	NA	NO,NA,NE	NA
E. Settlements	T2	CS,D	NO,NA	NA	NO,NA	NA
F. Other land	T2	CS,D	NO	NO	T1	D
G. Harvested wood products	T2,T3	CS,D				

D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country-specific method or emission factor

6.2. Land-use definitions and the classification systems used and their correspondence to the land use, land-use change and forestry categories

In accordance with the *2006 IPCC Guidelines*, all Japanese land is classified into 6 land-use categories. In Japan, as shown in Table 6-2, land is allocated in each land-use categories on the basis of the definitions in existing statistics. Area of each land-use category is identified by using value indicated in land classification in existing statistics. Land which is not be classified into the above five land use categories is defined as “Other Land”; the area of “Other Land” is determined by deducting the total area of five land use categories from total national land. As for forest land, cropland and grassland, country-specific subcategories are determined (forest land: forests with standing trees (intensively managed forests / semi-natural forests) / forests with less standing trees / bamboo; cropland: rice fields / upland fields / orchard / cultivation abandoned agricultural land; grassland: pasture land / grazed meadow land/ wild land). In addition, the definition of country-specific subcategory in forest land, which was established by Japan, is shown in Table 6-3.

Northernmost, Southernmost, Easternmost and Westernmost Points <http://www.gsi.go.jp/KOKUJYOHO/center.htm>.

Table 6-2 Criteria for land-use category allocation and sources of data and information to determine area

IPCC Land use category	Criteria for land-use category allocation	Sources of data and information to determine area
Forest	Forests under Forest Law Article 5 and 7.2.	Forests with standing trees (intensively managed forests, semi-natural forests), forests with less standing trees and bamboo in the forests which are included in the regional forests plan according to the *Forestry Status Survey* [-2004] and the *National Forest Resources Database* [2005-] (Forestry Agency).[3]
Cropland	Rice fields, upland fields, orchard and cultivation abandoned agricultural land	Rice fields, upland fields and orchard according to *Statistics of Cultivated and Planted Area* by the MAFF. Cultivation abandoned agricultural land according to *World Census of Agriculture and Forestry* by the MAFF.
Grassland	Pasture land, grazed meadow land, and wild land[4]. (excluding pasture land and grazed meadow land)	Pasture land according to *Statistics of Cultivated and Planted Area* by the MAFF, grazed meadow land (excluding when it is included in forest land) according to *World Census of Agriculture and Forestry* by the MAFF, and wild land according to *Land Use Status Survey* by the MLIT.
Wetlands	Lands covered with water (such as dams), rivers, and waterways.	Lands covered with water, rivers, and waterways according to *Land Use Status Survey, Survey of Forestry regions* by the MLIT. Among them, the lands that are subject to revegetation activities (e.g. green areas along rivers and erosion control sites, a part of urban parks) are allocated to settlements.
Settlements	Urban areas that do not constitute forest land, cropland, grassland or wetlands. Urban green areas are all wooded and planted areas that do not constitute forest land.	Settlements are roads, residential land, school reservations, park and green areas, road sites, environmental facility sites, golf courses, ski courses and other recreation sites identified in *Land Use Status Survey* and other surveys by the MLIT. The included figures for urban green areas are taken from the surveys on urban green facilities conducted by the MLIT. (Details are shown in Table 11-11).
Other land	Any land that does not belong to the above land-use categories.	Determined by subtracting the total area belonging to the other land-use categories from the total area of national land according to *Statistical Reports on the Land Area by Prefectures and Municipalities in Japan* by the Geospatial Information Authority of Japan (GSI).

MAFF: Ministry of Agriculture, Forestry and Fisheries; MLIT: Ministry of Land, Infrastructure, Transport and Tourism

Table 6-3 Definitions of forest subcategories

Forest subcategories		Definitions
Forest with standing trees		Forest that does not fall under "forest with less standing trees" and has a tree crown cover of standing trees 30% or higher (including young stands with the degree of stocking[5] of 3 or higher even though the tree crown cover is less than 30%). Even if the tree crown cover of standing trees is less than 30%, forest in which the sum of the crown covers of both standing trees and bamboo is 30% or higher, while dominated by standing trees, is also included
	Intensively managed forest:	Forest land that is subject to artificial regeneration such as tree planting and seeding, and in which no less than 50% of the volume (or the number) of standing trees are of tree species subject to artificial regeneration.
	Semi-natural forest	Forest with standing trees which is not classified as intensively managed forests
Forest with less standing trees		Forest in which the sum of the tree crown covers of both standing trees and bamboo is less than 30 percent.
Bamboo		Forest, other than “forest with standing trees”, in which a tree crown cover of bamboo (excluding bamboo grasses) is 30% or higher. Even if the tree crown cover of bamboo is less than 30%, forest in which the sum of the crown covers of both standing trees and bamboo is 30% or higher with bamboo being dominated is also included.

Reference: Forestry Agency of Japan, *Forest Status Survey* (March, 2007) *partially modified

In accordance with *2006 IPCC Guidelines*, each land use category is further classified into “Land remaining Land” and “Land converted to Land” depending on its history of land-use conversion; each

[3] The *Forestry Status Survey* and the *National Forest Resources Database* use the same definitions and survey methods for forests, and these two data bases have time-series consistency.

[4] Its present status is mainly wild grassland (including perennial pasture land, degenerated pasture land, and areas abandoned after cultivation and becoming wild).

[5] The degree of stocking is the ratio of actual volume to the expected volume of the forest stand, multiplied by 10.

area is calculated by estimation based on existing statistics. Among them, the areas of land converted to forest land are estimated based on data of the areas of afforestation and reforestation under Article 3, paragraph 3, of the Kyoto Protocol, which are determined by utilizing orthophotos taken at the end of 1989 and recent satellite images, in addition to existing statistics. The areas of forest land converted to other land-use categories are estimated based on data of the areas of deforestation determined in the same way as afforestation and reforestation, in addition to data of the *World Census of Agriculture and Forestry* and the Forestry Agency's records. For detailed information on the methods of determining the areas of afforestation, reforestation and deforestation, see section 11.4.2.3. in Chapter 11. In addition, Land-use categories that cannot be directly determined from existing statistics are determined using estimation measures such as allocation of areas of land conversion by means of the ratio of actual land areas for each land-use category.

6.3. Information on approaches used for representing land areas and on land-use database used for the inventory preparation

6.3.1. Survey methods and due dates of major land area statistics

Table 6-4 shows the survey methods and due dates of major land area statistics.

Table 6-4 Survey methods and due dates of major land area statistics

Name of the statistics / census		Survey method	Survey due date	Frequency	Presiding ministry
Forest Status Survey		Complete count survey	March, 31st	Approximately 5 years	MAFF (Forestry Agency)
National Forest Resources Database		Complete count survey	April, 1st	Every year (Since 2005)	MAFF (Forestry Agency)
Statistics of Cultivated and Planted Area (Survey of cropland area)	[Cropland area]	Ground measurement survey (sample)	July, 15th	Every year	MAFF
	[Expansion area and converted area of cropland]	Tabular survey (using documents from relevant agencies and aerial photographs, etc.)	July, 15th in the previous year until July, 14th		
World Census of Agriculture and Forestry		Complete count survey	[by 2000] August, 1st [from 2005] February, 1st	[by 2000] Every 10 years, [from 2005] every 5 years	MAFF
Land Use Status Survey		Complete count Survey	---	Every year	MLIT
Statistical Reports on the Land Area by Prefectures and Municipalities in Japan		Complete count Survey	October, 1st	Every year	GSI

Details for urban green facilities are shown in Table 11-11.

MAFF: Ministry of Agriculture, Forestry and Fisheries; MLIT: Ministry of Land, Infrastructure, Transport and Tourism

6.3.2. Land area estimation methods

Some land areas cannot be directly determined from existing statistics; therefore, they are estimated using the following methods:

- Interpolation
- Allocation of areas of land conversion by means of the ratio of actual land areas for each land-use category
- Allocation of areas of land conversion by means of the ratio of converted land areas for a certain

year

- ***Interpolation***

➢ ***Method***

The areas of forest land before 2004 were surveyed at an interval of approximately five years, and it was difficult to directly determine the areas of forest land in the unsurveyed years. Therefore, they were estimated by interpolation by means of linear expressions based on the areas in the surveyed years.

➢ ***Land-use category***

4.A.2. Land converted to Forest land (FY1991- 1994, 1996- 2001 and 2003- 2004).

- ***Allocation of areas of land conversion by means of the ratio of actual land areas for each land-use category***

➢ ***Method***

In Japan, it is difficult to obtain the areas of upland field converted to forest land, orchard converted to forest land and pasture land converted to forest land directly from existing statistics, since those are collectively reported as arable land. Therefore, these land areas were estimated by multiplying the arable land converted to forest land by the ratios of actual land areas for each of the land-use categories (upland field, orchard and pasture land).

➢ ***Land-use category***

4.A.2. Land (Cropland and Grassland) converted to Forest land
4.B.2. Land (Forest land, Grassland, Wetlands and Other land) converted to Cropland
4.C.2. Land (Forest land, Cropland, Wetlands and Other land) converted to Grassland
4.E.2. Land (Cropland and Grassland) converted to Settlements
4.F.2. Land (Cropland and Grassland) converted to Other land

- ***Allocation of areas of land conversion by means of the ratio of converted land area for a certain year***

➢ ***Method***

In Japan, it is difficult to directly obtain annual land areas of cropland, grassland, settlements and other land converted to wetlands, respectively. Therefore, the annual land ratios of cropland, grassland, settlements and other land converted to wetlands to land converted to wetlands in FY1998, which are assumed to be the same as the land ratio in each year, are multiplied by the areas of land converted to wetlands in each year to obtain the area of respective land use category converted to wetlands.

➢ ***Land use category***

4.D.2. Land (Cropland, Grassland, Settlements and Other land) converted to Wetlands

6.3.3. Land-use transition matrix

Land use transition matrix to determine land use conversion made in the FY has been annually produced since FY1990 until now, for six land use categories whose area identified in accordance with the description in section 6.2 and in the beginning part of section 6.3. In CRF, the newest fiscal year's matrix is reported in table 4.1. Land use conversion made in FY1990 and in FY2014 are displayed in the following Table 6-5 and Table 6-6 individually. In addition, land use matrix produced

by accumulating land conversion between each land use category, from FY1990 to FY2014, is shown in Table 6-7. In Japan, all lands are managed lands and land without management does not exist; therefore, the column for land without management is shaded in gray.

Table 6-5 Land-use transition matrix for Japan in FY1990

(kha)

Before Conversion \ After Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest Land	24,946.8	7.32	1.03	0.31	20.2	5.01	24,980.7
Cropland	2.71	4,805.0	0.9	0.02	21.4	2.16	4,832.2
Grassland	0.67	0.002	1,019.5	0.01	3.2	0.36	1,023.7
Wetlands	NO	0.34	0.12	1,318.4	IE	IE	1,318.9
Settlements	0.05	IE	NO	0.002	3,174.2	IE	3,174.3
Other land	0.05	0.21	0.01	0.09	IE	2,443.6	2,444.0
Total	24,950.3	4,812.9	1,021.6	1,318.8	3,219.0	2,451.2	37,773.7

Table 6-6 Land-use transition matrix for Japan in FY2014

(kha)

Before Conversion \ After Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest Land	25,113.7	0.79	0.13	0.16	5.78	0.47	25,121.1
Cropland	0.07	4,302.7	0.27	0.01	8.83	1.97	4,313.9
Grassland	0.01	0.003	947.3	0.004	1.64	0.27	949.2
Wetlands	0.0001	NO	NO	1,337.8	IE	IE	1,337.8
Settlements	0.03	IE	NO	0.001	3,790.8	IE	3,790.8
Other land	0.02	3.06	0.14	0.04	IE	2,281.2	2,284.5
Total	25,113.9	4,306.6	947.8	1,338.0	3,807.0	2,283.9	37,797.2

Table 6-7 Land-use transition matrix for FY1990-FY2014

(kha)

1990 \ 2014	Forest Land (managed)	Forest Land (unmanaged)	Cropland	Grassland (managed)	Grassland (unmanaged)	Wetlands (managed)	Wetlands (unmanaged)	Settlements	Other land	Total unmanaged land	Initial area
Forest Land (managed)	25078.3		34.1	6.1		14.9		238.9	64.1		25436.5
Forest Land (unmanaged)											
Cropland	25.3		4247.6	21.2		1.1		344.0	59.2		4698.4
Grassland (managed)	5.8		0.5	919.1		0.4		52.7	7.9		986.3
Grassland (unmanaged)											
Wetlands (managed)	0.02		1.1	0.4		1317		IE	IE		1319.0
Wetlands (unmanaged)											
Settlements	2.8		IE	NO		0.1		3171.4	IE		3174.3
Other land	1.7		23.3	0.9		4.1		IE	2152.7		2182.7
Total unmanaged land											
Final area	25113.9		4306.6	947.8		1338.0		3807.0	2283.9		37797.2
Net change	-322.6		-391.8	-38.5		19.0		632.7	101.2		0

Note: The areas described as “IE” are included in “Other lands remaining the sane land-use category” which could be used for adjustment with total area of national land.

6.4. Parameters for estimating carbon stock changes from land use conversions

Prior to the sections describing detailed methods for each land-use category, basic parameters used for estimating carbon stock changes due to land use conversions are shown here (Table 6-8a to Table 6-11) to prevent the reiteration of indicating these parameters in each subsequent section. The method of establishing some parameters, calculation method, and ground for establishing them are shown in "Note". Please refer to each section specified in Note. In case that notation "-" is used in table instead of describing numbers and description is separately made, please also refer to "Note" since the case may be under examination.

As for parameter whose value is indicated as "0", there are following three cases: in accordance with IPCC 2006 guidelines, default value, "0", is applied; carbon stock changes but no calculation methodology exists; it is assumed "0" under the presumption that there was no change. For details, please refer to "Note".

Table 6-8a Living biomass stocks for each land-use category before and immediately after conversion

Land use category			Biomass stock or Carbon stock	Note
Before conversion	Forest land		99.1 [t-d.m./ha] (FY2014)	Calculated by utilizing the values of biomass stocks in land of deforestation under Article 3, paragraph 3, of the Kyoto Protocol, which are provided from the NFRDB. In addition, the values before FY2007 are substituted by the average value between FY2008 and FY2012. (Reference values [t-d.m./ha]: FY1990: 103.3, FY2005: 103.3, FY2008: 129.0, FY2009: 115.9, FY2010: 70.7, FY2011: 91.6, FY2012: 109.2, FY2013: 98.5)
	Cropland	Rice field	0	Biomass stocks are assumed to be "0".
		Upland field	0	Biomass stocks are assumed to be "0".
		Orchard	IE	Included in cropland remaining cropland.
	Grassland		13.50 [t-d.m./ha]	Default value (Table 6.4 : "warm temperate wet", Volume 4 of the 2006 IPCC Guidelines)
	Wetlands, settlements and other land		0	Biomass stocks are assumed to be "0".
Immediately after conversion	All land uses		0	Biomass stocks are assumed to be "0".

Table 6-8b Living biomass growth increments for each land-use category after conversion

Land use category			Biomass growth increment	Note
After conversion	Forest land		2.9 [t-d.m./ha/yr]	Removals in this land are directly estimated based on the implied removal factor of AR activity under the Kyoto Protocol. The average value between FY2008 and FY2010 are applied to all reporting years.
	Cropland	Rice field	0	Biomass stocks are assumed to be "0".
		Upland field	0	Biomass stocks are assumed to be "0".
		Orchard	IE	Included in cropland remaining cropland.
	Grassland		2.70 [t-d.m./ha/yr]	Default value (Table 6.4: One fifth of the value 13.5 at "warm temperate wet", the 2006 IPCC Guidelines)
	Settlements		-	See section 6.9.2.b)1)
	Wetlands and other land		0	Biomass growth increment are assumed to be "0".

Table 6-9 Carbon stocks of dead wood for each land-use category before and after conversion

Land-use Category		Carbon Stock	Note
Before Conversion	Forest land	14.84 [t-C/ha] (FY2014)	Calculated from carbon stocks in dead wood in all forests. In addition, the values before 2004 are substituted by the value of FY2005.(Reference values [t-C/ha]: FY1990: 15.08, FY2005: 15.08, FY2008: 15.02, FY2009: 14.99, FY2010: 14.97, FY2011: 14.95, FY2012: 14.93, FY2013:14.89)
	Cropland, grassland, wetlands, settlements, other land	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
Immediately after conversion	All land uses	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1) Carbon stocks immediately after conversion are assumed to be “0”.
After conversion	Forest land	13.01 [t-C/ha]	Average carbon stocks per unit area in 20-year-old forests obtained by the CENTURY-jfos model
	Cropland, grassland, wetlands, other land	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
	Settlements	0	Default value (Section 8.3.2 in Volume 4 of the 2006 IPCC Guidelines, Tier 1)

Table 6-10 Carbon stocks of litter for each land-use category before and after conversion

Land-use Category		Carbon Stock	Note
Before Conversion	Forest land	7.30 [t-C/ha] (FY2014)	Calculated from carbon stocks in litter in all forests. In addition, the values before 2004 are substituted by the value of FY2005. (Reference values [t-C/ha]: FY1990: 7.24, FY2005: 7.24, FY2008: 7.26, FY2009: 7.27, FY2010: 7.28, FY2011: 7.28, FY2012: 7.29, FY2013: 7.29)
	Cropland, grassland, wetlands, settlements, other land	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
Immediately after conversion	All land-uses	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1) Carbon stocks immediately after conversion are assumed to be “0”.
After conversion	Forest land	5.637 [t-C/ha]	Average carbon stocks per unit area in 20-year-old forests obtained by the CENTURY-jfos model
	Cropland, grassland, wetlands, other land	0	Default value (Section 5.3.2 etc. in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
	Settlements	-	See section 6.9.2.b)2)

Table 6-11 Carbon stocks of soil for each land-use category before and after conversion

Land-use Category			Carbon Stock	Note
Before conversion	Forest land		85.35[t-C/ha] (FY2014)	Value of soil carbon stocks at 0-30 cm depth one year before the inventory year. National average value calculated by the CENTURY-jfos model. In addition, the value in FY2005 is applied to the years before 2004. (Reference values [t-C/ha]: FY1990: 85.07, FY2005: 85.07, FY2008: 85.14, FY2009: 85.12, FY2010: 85.17, FY2011: 85.20, FY2012: 85.30, FY2013: 85.33)
	Cropland	Rice field	71.38 [t-C/ha]	Value of soil carbon stocks at 0-30 cm depth. Data provided from Dr. Makoto Nakai, National Institute for Agro-Environmental Sciences (Undisclosed) * These carbon stocks were not applied to "cropland converted to grassland" and "grassland converted to cropland".
		Upland field	86.97 [t-C/ha]	
		Orchard	77.46 [t-C/ha]	
		Cropland (average)	76.40 [t-C/ha]	
	Grassland		134.91 [t-C/ha]	
	Wetlands		88.00 [t-C/ha]	Default value (2006 IPCC Guidelines Table 2.3, Wetland soils/ Warm temperate).
	Settlements		-	Under investigation
	Other land		-	This value is determined depending on land conversion status.
After conversion	Forest land		82.907 [t-C/ha]	Value of soil carbon stocks at 0-30 cm depth. Average carbon stocks per unit area in 20-year-old forests obtained by the CENTURY-jfos model.
	Cropland		IE	Included in cropland remaining cropland.
	Grassland		IE	Included in grassland remaining grassland.
	Wetlands		-	Under investigation
	Settlements		-	These values are determined depending on land conversion status.
	Other land		-	

* All carbon stocks in mineral soils before conversion to forest land are regarded as 80 t-C/ha due to expert judgment.

6.5. Forest land (4.A.)

Forests absorb CO_2 from the atmosphere by photosynthesis, fix carbon as organic substances, and store these substances for a given period. In contrast, forests emit CO_2 due to the effects of events such as logging and natural disturbances.

All forests in Japan are managed forests, and they consist of intensively managed forests, semi-natural forests, bamboo, and forests with less standing trees. Japan's forest land area in FY2014 was about 25.1 million ha—about 66.4% of the total national land area. The net removal by this category in FY2014 was 65,382 kt-CO_2 (excluding 24.69 kt-CO_2 eq. of CH_4 and N_2O emissions resulting from biomass burning, 0.56 kt-CO_2 eq. of N_2O emission resulting from N fertilization in forest land, and 126.0 kt-CO_2 eq. of N_2O emission from nitrogen mineralization resulting from change of land use or management of mineral soils). This represents a decrease of 17.3% below the FY1990 value, and a decrease of 4.1% below the FY2013 value. This declining trend in removals in recent years is considered due to the maturity of Japanese forests.

In this section, forest land is divided into two subcategories: "Forest land remaining Forest land (4.A.1.)" and "Land converted to Forest land (4.A.2.)", and they are described separately in the following subsections.

Table 6-12 Emissions and removals in forest land resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.A. Forest land	Total	kt-CO_2	-79,073	-87,612	-90,642	-92,664	-86,820	-85,556	-80,350	-75,511	-76,049	-77,819	-77,404	-68,174	-65,382
		Living Biomass	kt-CO_2	-73,014	-79,832	-83,665	-87,554	-82,293	-81,580	-76,902	-72,738	-73,911	-76,243	-76,271	-67,327	-64,706
		Dead Wood	kt-CO_2	-2,860	-3,803	-2,837	-1,082	-634	-206	186	680	1,159	1,562	1,863	2,017	2,064
		Litter	kt-CO_2	-2,697	-2,352	-1,774	-1,078	-939	-827	-745	-621	-529	-456	-412	-378	-348
		Mineral soil	kt-CO_2	-503	-1,625	-2,367	-2,950	-2,954	-2,942	-2,889	-2,833	-2,768	-2,681	-2,584	-2,486	-2,392
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	4.A.1. Forest land remaining Forest land	Total	kt-CO_2	-76,997	-86,583	-89,904	-92,109	-86,293	-85,053	-79,839	-75,055	-75,605	-77,411	-77,018	-67,812	-65,043
		Living Biomass	kt-CO_2	-71,504	-79,083	-83,129	-87,150	-81,909	-81,214	-76,531	-72,406	-73,588	-75,946	-75,990	-67,064	-64,459
		Dead Wood	kt-CO_2	-2,518	-3,634	-2,715	-991	-548	-124	271	755	1,232	1,629	1,926	2,076	2,120
		Litter	kt-CO_2	-2,548	-2,279	-1,721	-1,038	-901	-791	-708	-589	-498	-427	-384	-352	-324
		Mineral soil	kt-CO_2	-426	-1,587	-2,340	-2,930	-2,935	-2,924	-2,870	-2,816	-2,751	-2,666	-2,570	-2,473	-2,380
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	4.A.2. Land converted to Forest land	Total	kt-CO_2	-2,077	-1,029	-738	-555	-526	-503	-511	-457	-444	-408	-386	-362	-338
		Living Biomass	kt-CO_2	-1,509	-748	-536	-404	-384	-366	-371	-332	-322	-297	-281	-264	-247
		Dead Wood	kt-CO_2	-342	-170	-122	-92	-86	-83	-84	-75	-73	-67	-63	-59	-55
		Litter	kt-CO_2	-148	-73	-53	-40	-37	-36	-37	-33	-32	-29	-27	-26	-24
		Mineral soil	kt-CO_2	-77	-38	-27	-20	-19	-18	-19	-17	-16	-15	-14	-13	-12
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

6.5.1. Forest land remaining Forest land (4.A.1.)

a) Category Description

This subcategory deals with carbon stock changes in forest land remaining forest land, which has remained forested without conversion for the past 20 years as of FY2014. The net removal by this subcategory in FY2014 was 65,043 kt-CO_2 (excluding GHG emissions other than carbon stock changes). This represents a decrease of 15.5% over the FY1990 value and a decrease of 4.1% below the FY2013 value. Net removals in forest land remaining forest land have been decreasing continuously since 2003. This declining trend in removals in recent years is considered to be due to the maturity of Japanese forests. Nonetheless, removals per year fluctuate because annual quantity of harvesting domestic timber is changed depending on increase and decrease of demand on the domestic timber due to economic trends.

Five carbon pools in bamboo in forest land remaining forest land are all reported as “NA” because annual growth and death of bamboo trunk in established bamboo are equivalent. Bamboo does not have a vascular cambium Therefore, it reaches the limit of growth in the first year of the emergence and then do not exhibit secondary growth.

It is said that annual growth and death of bamboo trunk are almost equivalent in bamboo forests which reach the constant density in general. FAO conducted a survey (2007) on bamboo resources in 1990, 2000, and 2005 in several Asian and African countries. They reported that the carbon stock changes per unit area for five years (2000-2005) in each country had remained the same. The result of the survey supported the view that annual growth and death of bamboo trunk are almost equivalent.

With respect to forests with less standing trees, carbon stock changes in living biomass are estimated, and those in dead organic matter and soils are reported as “NA” because gains and losses of carbon stocks in the dead organic matter and soils are equivalent on a long-term basis.

The carbon stock changes in dead organic matter in forest land remaining forest land were net removals for the years 1990–2008 and net emissions since 2009. The change in the trend is due to the age classes of the intensively managed forests where thinning and harvesting are cyclic, causing annual variations in the contributions to the dead wood pool. Concretely speaking, harvesting in

forests planted in 1960s was implemented in 1990s, and transition of carbon stocks from living biomass to dead organic matter was promoted. However, quantity of harvesting decreased afterwards; hence, the carbon stock gains transmitted to dead organic matter were decreased, and carbon stock losses due to decomposition of the transmitted dead organic matter were increased. The carbon stock losses in the dead organic matter came to be bigger than the carbon stock gains in the pool in 2009. As a result, the carbon stock changes were net removal from 1990 to 2008, and net emissions since 2009.

b) Methodological Issues

1） Carbon stock changes in Living Biomass in "Forest land remaining Forest land"

- ***Estimation Method***

In accordance with the decision tree provided in the *2006 IPCC Guidelines*, carbon stock changes in living biomass in all forest land are estimated by the Tier 2 stock difference method using the country specific values of the amount of biomass accumulation. In this method, the carbon stock change in the living biomass pool is estimated by calculating the difference between the absolute amounts of carbon stocks in the pool at two points of time[6].

$$\Delta C_{LB} = \sum_k \left\{ (C_{t2} - C_{t1}) / (t_2 - t_1) \right\}_k$$

ΔC_{LB} : annual change in carbon stocks in living biomass [t-C/yr]
t_1, t_2 : time points of carbon stock measurement
C_{t1} : total carbon in biomass calculated at time t_1 [t-C]
C_{t2} : total carbon in biomass calculated at time t_2 [t-C]
k : type of forest management

The carbon stocks in living biomass are calculated by multiplying the stand volume of each tree species by wood density, the biomass expansion factor, the root-to-shoot ratio and the carbon fraction of dry matter. These parameters except the carbon fraction are determined for each tree species.

$$C = \sum_j \left\{ [V_j \cdot D_j \cdot BEF_j] \cdot (1 + R_j) \cdot CF \right\}$$

C : carbon stock in living biomass [t-C]
V : merchantable volume [m^3]
D : wood density [t-d.m./m^3]
BEF : biomass expansion factor for conversion of merchantable volume
R : root-to-shoot ratio
CF : carbon fraction of dry matter [t-C/t-d.m.]
j : tree species

Since Japan calculates the carbon stock change of living biomass in the total forest land in this manner, the carbon stock change of living biomass in forest land remaining forest land is obtained by subtracting the carbon stock change in land converted to forest land from the total change. For the

[6] Japan, as described below, estimates carbon stocks in living biomass using data from the National Forest Resources Database which is developed based on Forest Register's data from prefectures or Regional Forest Offices of National Forests. There are circumstances in which prefectures or Regional Forest Offices revise Forest Registers' data like tree species or areas when they update them so that the correct status of forests can be reflected. In this circumstance, modification of carbon stock changes in living biomass is implemented in order to obtain correct carbon stock change values. Without the modification, difference between carbon stock without revision at time point t_1 and carbon stock with revision at time point t_2 under the stock change method would not reflect the correct carbon stock changes.

method of estimating carbon stock change in land converted to forest land, see section 6.5.2.b)1).

- ***Parameters***

➢ ***Volume***

The Forestry Agency has developed the National Forest Resources Database (NFRDB) in order to estimate GHG emissions/removals from forests. The data in the NFRDB are based on the information on areas, tree species and forest ages, contained in the "Forest Registers" prepared by prefectures or Regional Forest Offices.

Merchantable volumes are estimated by multiplying the areas for each tree species and forest age in the NFRDB by merchantable volumes per area for each tree species and forest age in yield tables. Base data for the volumes per area are shown in Table 6-13 below. With respect to estimating the volumes of Japanese cedar, Hinoki cypress and Japanese larch in private forests, which are major tree species of intensively managed forests in Japan, the volumes per area reported in new yield tables, reflecting the newest survey results, are applied.

$$V = \sum_{m,j} (A_{m,j} \cdot v)$$

V : merchantable volume [m^3]
A : area [ha]
v : merchantable volume per area [m^3/ha]
m : age class or forest age
j : tree species

Table 6-13 Yield tables used to estimate merchantable volume

<table>
<tr><th colspan="3" rowspan="2">Tree species</th><th colspan="2">Yield tables</th></tr>
<tr><th>Private Forest</th><th>National Forest</th></tr>
<tr><td rowspan="3">Intensively managed forests</td><td rowspan="2">Conifer</td><td>Japanese cedar, Hinoki cypress, Japanese larch</td><td>New yield tables</td><td rowspan="4">Yield tables developed by Regional Forest Offices</td></tr>
<tr><td>Other conifer</td><td rowspan="3">Yield tables developed by prefectures</td></tr>
<tr><td colspan="2">Broad leaf</td></tr>
<tr><td colspan="3">Semi-natural forests</td></tr>
</table>

- ***Forest Registers and yield tables developed by prefectures or Regional Forest Offices***

When forest plans are established for private and national forests (all forest lands are divided into 158 planning areas, and forest plans are established each year for 1/5 [about 30] of them), field surveys are implemented in these forests to develop a Forest Register which includes data on area, forest age, volume by tree species and so on. When forest plans are established (private forests: by each prefecture, national forests: by Regional Forest Offices of National Forests), the Forest Registers are updated to reflect the change in volume due to growth, cutting and disturbances. In general, the volume data described in the Forest Registers are estimated based on land area data and yield tables, which provide stand growth in the case that typical forest practices are implemented for each region, tree species and site class (yield tables show the relationship between forest age or age class and volume per area).

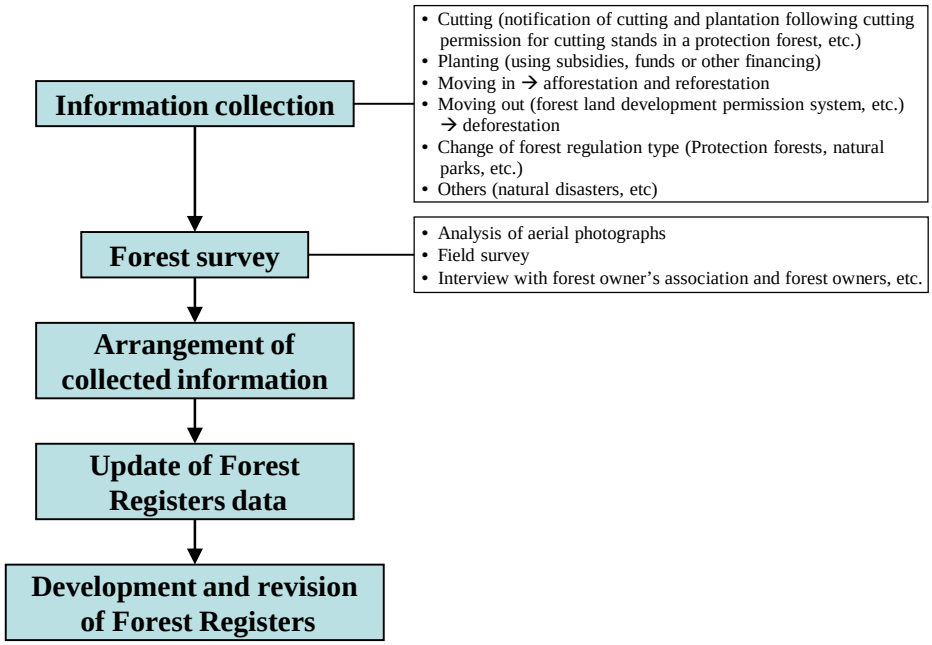

Figure 6-1 Procedures for developing Forest Registers

- ***New yield tables (Japanese cedar, Hinoki cypress, Japanese larch)***

In 2006, the Forestry and Forest Products Research Institute developed new yield tables for Japanese cedar, Hinoki cypress and Japanese larch based on the results of a field survey over the country. The area of these three tree species covers 82% of intensively managed forests in private forests.

The new yield tables for Japanese cedar were established for 7 regions, those for Hinoki cypress for 4 regions and those for Japanese larch for 2 regions.

➢ ***Biomass expansion factor and Root-to-shoot ratio***

The biomass expansion factors (BEF) and root-to-shoot ratios (R) were set based on the results from a biomass survey on dominant tree species, and existing research reports which were implemented by the Forestry and Forest Products Research Institute (Table 6-14).

BEFs were calculated for two age classes (20 years and below / 21 years and above) and for each tree species, because it was identified that BEFs differed between young forests and mature forests. On the other hand, R values were established only for tree species, because the root-to-shoot ratio was not correlated with forest age.

➢ ***Wood density***

Wood density (D) data were set based on the results from biomass survey on dominant tree species and existing research reports which were implemented by the Forestry and Forest Products Research Institute (Table 6-14). These D values were established only for tree species, because wood density was not correlated with forest age.

➢ ***Carbon fraction of dry matter***

The country specific value set based on Japan's research result has been adopted as the carbon fraction (CF) of dry matter (Table 6-14).

Table 6-14 Biomass expansion factor, root-to-shoot ratio, wood density for tree species and carbon fraction

		BEF [-]		R	D	CF	Note
		≦20	＞20	[-]	[t-d.m./m^3]	[t-C./t-d.m]	
Conifer trees	Japanese cedar	1.57	1.23	0.25	0.314	0.51	
	Hinoki cypress	1.55	1.24	0.26	0.407		
	Sawara cypress	1.55	1.24	0.26	0.287		
	Japanese red pine	1.63	1.23	0.26	0.451		
	Japanese black pine	1.39	1.36	0.34	0.464		
	Hiba arborvitae	2.38	1.41	0.20	0.412		
	Japanese larch	1.50	1.15	0.29	0.404		
	Momi fir	1.40	1.40	0.40	0.423		
	Sakhaline fir	1.88	1.38	0.21	0.318		
	Japanese hemlock	1.40	1.40	0.40	0.464		
	Yezo spruce	2.18	1.48	0.23	0.357		
	Sakhaline spruce	2.17	1.67	0.21	0.362		
	Japanese umbrella pine	1.39	1.23	0.20	0.455		
	Japanese yew	1.39	1.23	0.20	0.454		
	Ginkgo	1.50	1.15	0.20	0.450		
	Exotic conifer trees	1.41	1.41	0.17	0.320		
	Other conifer trees	2.55	1.32	0.34	0.352		Applied to Hokkaido, Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima, Tochigi, Gunma, Saitama, Niigata, Toyama, Yamanashi, Nagano, Gifu and Shizuoka prefectures
		1.39	1.36	0.34	0.464		Applied to Okinawa prefecture
		1.40	1.40	0.40	0.423		Applied to prefectures other than above
Broad leaf trees	Japanese beech	1.58	1.32	0.26	0.573	0.48	
	Oak (evergreen tree)	1.52	1.33	0.26	0.646		
	Japanese chestnut	1.33	1.18	0.26	0.419		
	Japanese chestnut oak	1.36	1.32	0.26	0.668		
	Oak (deciduous tree)	1.40	1.26	0.26	0.624		
	Japanese popular	1.33	1.18	0.26	0.291		
	Alder	1.33	1.25	0.26	0.454		
	Japanese elm	1.33	1.18	0.26	0.494		
	Japanese zelkova	1.58	1.28	0.26	0.611		
	Cercidiphyllum	1.33	1.18	0.26	0.454		
	Japanese big-leaf	1.33	1.18	0.26	0.386		
	Maple tree	1.33	1.18	0.26	0.519		
	Amur cork	1.33	1.18	0.26	0.344		
	Linden	1.33	1.18	0.26	0.369		
	Kalopanax	1.33	1.18	0.26	0.398		
	Paulownia	1.33	1.18	0.26	0.234		
	Exotic broad leaf trees	1.41	1.41	0.16	0.660		
	Japanese birch	1.31	1.20	0.26	0.468		
	Other broad leaf trees	1.37	1.37	0.26	0.469		Applied to Chiba, Tokyo, Kochi, Fukuoka, Nagasaki, Kagoshima, and Okinawa prefectures
		1.52	1.33	0.26	0.646		Applied to Mie, Wakayama, Oita, Kumamoto, Miyazaki, and Saga prefecture
		1.40	1.26	0.26	0.624		Applied to prefectures other than above

BEF: Biomass expansion factor (20 = age class)
R: Root-to-shoot ratio
D: Wood density
CF: Carbon Fraction

- ***Activity Data (Area)***

➢ ***Determining the forest area***

Forest areas of intensively managed forests, semi-natural forests, forests with less standing trees and bamboo under the forest planning system are obtained from the “Forest Status Survey” for years earlier than FY2004 and from the National Forest Resource Database (NFRDB) for FY2005 and

onward. Data for FY1991 through FY1994, FY1996 through FY2001, and FY2003 through FY2004 are estimated by interpolation by means of linear expression. In addition, area data of Sakhalin fir, Yezo spruce, Japanese chestnut oak and Oak (deciduous tree) before FY1990 are not available individually; therefore, these data are estimated from "other conifer" and "other broad leaf" area divided by the area ratio in FY1995.

Table 6-15 Classifications in Forest Status Survey (before 2004) and National Forest Resource Database (after 2005)

Conifer trees		Broad leaf trees	
Before 2004	After 2005	Before 2004	After 2005
Japanese cedar	Japanese cedar	Japanese chestnut oak	Japanese chestnut oak
Hinoki cypress	Hinoki cypress	Oak (deciduous tree)	Oak (deciduous tree)
Pine	Japanese red pine	Other broad leaf	Japanese beech
	Japanese black pine		Oak (evergreen tree)
Japanese larch	Japanese larch		Japanese chestnut
Sakhalin fir	Sakhalin fir		Japanese poplar
Yezo spruce	Yezo spruce		Alder
	Sakhalin spruce		Japanese elm
Other conifer	Sawara cypress		Japanese zelkova
	Hiba arborvitae		Cercidiphyllum
	Momi fir		Japanese big-leaf magnolia
	Japanese hemlock		Maple tree
	Japanese umbrella pine		Amur cork
	Japanese yew		Japanese lime
	Ginkgo		Linden
	Exotic conifer trees		Kalopanax
	Other needle leaf		Paulownia
			Exotic broad leaf trees
			Other broad leaf

➢ ***Obtaining the land area of "Forest land remaining Forest land"***

This land area is estimated by subtracting the cumulative total area of land converted to forest land" during the past 20 years from the total area of forest land in the year subject to estimation. All areas of land converted to forest land are assumed to be intensively managed forests. For the activity data of land converted to forest land, see section 6.5.2.b)1).

Table 6-16 Area of forest land remaining forest land within the past 20 years

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Forest land remaining Forest land		kha	24,806.8	24,825.8	24,825.0	24,953.8	24,950.3	24,947.9	24,933.7	24,916.4	24,935.5	24,940.0	24,932.9	25,127.2	25,090.7
	Intensively managed forests	kha	10,144.3	10,284.5	10,279.5	10,298.1	10,296.3	10,285.5	10,273.0	10,266.9	10,254.3	10,252.5	10,245.2	10,216.0	10,201.8
	Semi-natural forests	kha	13,354.5	13,220.3	13,195.2	13,315.7	13,306.2	13,321.5	13,333.5	13,349.6	13,360.8	13,359.5	13,355.2	13,368.9	13,380.9
	Cut-over forests and lesser stocked forests	kha	1,159.0	1,171.0	1,197.4	1,186.0	1,193.1	1,184.7	1,170.8	1,142.8	1,161.7	1,169.0	1,170.8	1,391.2	1,355.6
	Bamboo	kha	149.0	150.0	152.9	154.0	154.7	156.2	156.4	157.1	158.6	159.1	161.7	151.1	152.4

Source: *Forest Status Survey, National Forest Resources Database* (Forestry Agency)

2） Carbon Stock Changes in Dead Organic Matter and Soils in "Forest land remaining Forest land"

● ***Estimation Method***

In accordance with the decision tree provided in the *2006 IPCC Guidelines*, these pools are estimated by the Tier 3 method.

Carbon stock changes in pools of dead wood, litter and mineral soils are estimated by multiplying

average carbon stock changes per unit area per forest management type by the land area of each forest management type.

$$\Delta C_{dls} = \sum_{k,m,j} \left\{ A_{k,m,j} \times (d_{k,m,j} + l_{k,m,j} + s_{k,m,j}) \right\}$$

$\triangle C_{dls}$: Annual change in carbon stocks in dead wood, litter and soil [t-C/yr]
A : Area [ha]
d : Average carbon stock change per unit area in dead wood [t-C/ha/yr]
l : Average carbon stock change per unit area in litter [t-C/ha/yr]
s : Average carbon stock change per unit area in soil [t-C/ha/yr]
k : Type of forest management
m : Age class or forest age
j : Tree species

In Japan, it is not thought probable that the trouble would be taken to do drainage and plant trees on land with organic soil not suitable for the growing of forestry tree species, when forestry management have been at severe condition during some decades. Moreover, there are many cases where areas with organic soil have a precious natural environment, and the change of the land configuration or character are being regulated in these places by law and regulations. In addition, when we consulted with persons who have demonstrable expertise in forest soil environments, it was confirmed that they have never heard of such cases of soil drainage in forest lands with organic soils in Japan. Given the above, it is thought that soil drainage in forest land with organic soils is not implemented in Japan; therefore the emissions for this category are reported as “NO”.

- ***Parameters***

Average carbon stock changes per unit area for dead wood, litter and soils are calculated by the CENTURY-jfos model, which was modified from the CENTURY model (Colorado State University) to be applicable to Japanese climate, soil, and vegetation conditions.

- ***Assumptions and Parameters as the Keys for the CENTURY-jfos Model***

Since the amounts of tree growth and stable soil carbon stocks were thought to vary depending on climatic or locational conditions, the data of climatic values and soil carbon stocks were aggregated for each tree species in each prefecture (Table 6-17). It was assumed that forests have continually existed and been routinely utilized, and that their soil carbon stocks have been in a nearly steady state. Next, the parameters in the CENTURY-jfos model were adjusted. First, the growth parameters of above-ground biomass were adjusted so that the model be fitted to the growth in the yield tables in association with climatic values calculated per prefecture and per tree species. Second, the parameters were adjusted so that soil carbon stocks after the 60-year cutting age after a spinup of 3,000 years be fitted to the parameters for each of the prefectures and tree species calculated by Morisada et al. (2004). The methodologies of adjusting each parameter are in accordance with Sakai *et al*. (2010).

Tuning of the CENTURY-jfos Model

The Forestry and Forest Products Research Institute adjusted the CENTURY model in order to apply it to the Japanese forest environment. That is, forests were classified by predominant tree species (Japanese Cedar, Hinoki Cypress, Pine species, Japanese Larch, Sakhaline Fir, Sakhaline Spruce, broad leaf trees, and other conifer trees), and the geographical distribution of the tree species and soil types underneath were identified for each prefecture. The climate conditions to run the model were prepared from the mesh climate data provided by the Meteorological Agency of Japan (Japan Meteorological Agency, 2002). The model was adjusted with parameters on tree growth so that the tree growth in the model conformed to yield tables, and it was also tuned so that its output of carbon stocks in soil conformed to actual values based on field surveys for each prefecture and tree species (Table 6-17). The model after these modifications was named as the CENTURY-jfos model. After the tuning, carbon stocks in dead wood, litter and soil, and their stock changes were calculated by the CENTURY-jfos for different types of forest management such as management with thinning or without thinning.

Average annual carbon stock changes per unit area in dead wood, litter and soil are calculated for 1 – 19 age classes (for 100 years) for each type of forest management by means of CENTURY-jfos in order to estimate carbon stock changes in these carbon pools using the same activity data as for living biomass.

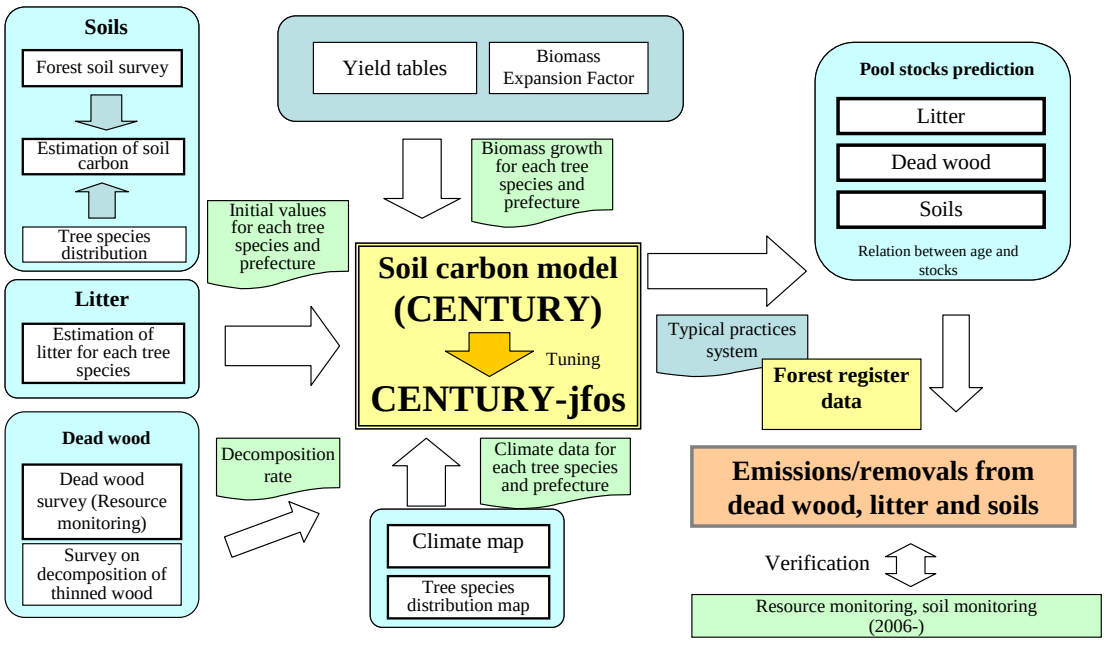

Figure 6-2 Estimation of emissions/removals in dead wood, litter and soils

Table 6-17 Standard soil carbon stocks used for the CENTURY-jfos model

(t-C/ha [30 cm depth])

Prefecture No.	Prefecture	Tree Species							
		Japanese Cedar	Hinoki Cypress	Pine species	Japanese Larch	Sakhaline Fir	Sakhaline Spruce	Broad Leaf Trees	Other Conifer Trees
1	Hokkaido	98.0	NA	95.0	91.0	88.0	93.7	91.0	83.5
2	Aomori	92.1	NA	94.3	83.3	109.1	NA	89.0	89.8
3	Iwate	89.5	93.6	92.7	93.9	98.1	NA	91.3	93.3
4	Miyagi	86.1	70.8	78.5	90.3	110.9	NA	82.8	80.5
5	Akita	81.1	NA	72.4	81.0	108.5	NA	82.6	79.6
6	Yamagata	83.2	79.7	68.0	81.0	97.4	NA	74.4	76.9
7	Fukushima	84.3	83.7	81.1	89.3	108.6	NA	81.4	85.0
8	Ibaraki	84.3	83.4	97.6	NA	NA	NA	91.2	90.8
9	Tochigi	83.0	86.1	91.6	100.6	133.4	NA	93.1	96.4
10	Gunma	88.7	88.3	93.9	95.1	98.1	NA	86.5	93.9
11	Saitama	81.3	82.4	96.2	106.8	NA	NA	85.8	94.7
12	Chiba	93.9	85.7	65.6	NA	NA	NA	84.6	76.4
13	Tokyo	79.2	81.6	85.7	94.7	NA	NA	63.9	84.3
14	Kanagawa	91.9	99.8	89.8	NA	NA	NA	94.9	99.1
15	Niigata	83.9	51.3	63.4	86.7	133.0	NA	85.3	86.9
16	Toyama	90.3	NA	72.5	88.5	106.0	NA	94.5	100.2
17	Ishikawa	82.7	80.2	70.2	NA	133.4	NA	86.6	74.3
18	Fukui	88.7	85.8	79.8	NA	NA	NA	90.1	80.6
19	Yamanashi	93.0	93.9	98.0	99.3	NA	NA	93.9	95.6
20	Nagano	102.1	100.5	96.0	108.4	106.0	NA	97.9	103.3
21	Gifu	100.5	94.8	79.1	99.6	107.8	NA	95.8	93.9
22	Shizuoka	94.6	96.7	69.1	90.7	NA	NA	90.0	93.7
23	Aichi	91.2	85.0	60.1	NA	NA	NA	78.5	77.2
24	Mie	92.1	84.4	63.8	97.1	NA	NA	78.7	80.5
25	Shiga	83.5	73.0	59.6	NA	NA	NA	79.5	65.8
26	Kyoto	74.0	67.4	63.3	NA	NA	NA	66.4	64.6
27	Osaka	78.9	74.0	60.9	NA	NA	NA	67.5	66.0
28	Hyogo	88.3	71.8	53.0	123.6	NA	NA	63.4	61.9
29	Nara	79.6	69.8	65.5	NA	NA	NA	73.4	69.4
30	Wakayama	72.1	70.5	58.2	NA	NA	NA	62.8	69.9
31	Tottori	73.8	74.9	75.6	121.2	NA	NA	72.3	75.4
32	Shimane	69.0	66.6	61.2	77.3	NA	NA	64.6	63.2
33	Okayama	80.3	73.7	51.4	121.2	NA	NA	65.2	63.6
34	Hiroshima	74.0	71.8	54.0	71.2	NA	NA	65.0	58.7
35	Yamaguchi	64.9	60.9	49.3	NA	NA	NA	55.2	54.8
36	Tokushima	72.9	63.7	63.6	NA	NA	NA	66.7	63.7
37	Kagawa	57.7	61.9	56.6	NA	NA	NA	57.2	57.7
38	Ehime	80.1	75.1	63.2	85.4	NA	NA	67.4	74.1
39	Kochi	81.4	76.1	73.8	NA	NA	NA	74.1	76.2
40	Fukuoka	97.3	88.9	77.5	NA	NA	NA	86.5	88.3
41	Saga	83.6	83.0	69.1	NA	NA	NA	79.6	82.9
42	Nagasaki	82.9	84.5	82.6	NA	NA	NA	78.9	84.5
43	Kumamoto	108.7	96.0	79.3	NA	NA	NA	93.5	95.6
44	Oita	109.9	100.5	108.3	130.3	NA	NA	99.1	101.4
45	Miyazaki	106.1	102.0	93.7	NA	NA	NA	98.0	99.6
46	Kagoshima	108.4	102.4	75.7	NA	NA	NA	90.8	97.0
47	Okinawa	58.5	NA	58.9	NA	NA	NA	58.0	58.5

- ***Activity Data (Area)***

Forest area data provided by the NFRDB were used for the estimation as activity data input to CENTURY-jfos model. In addition, areas of organic soils in forest land were estimated as reference values by means of soil maps and status of distribution of organic soils in each prefecture. Furthermore, organic soils exist only in semi-natural forests in Japan; hence, all areas of organic soils are reported in semi-natural forests, and areas of organic soils in intensively managed forests, bamboo and forests with less standing trees are reported as “NO”.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of the parameters and activity data for living biomass were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty estimates for dead organic matter and soil were assessed by calculating the variance of outputs from the CENTURY-jfos model. As a result, the uncertainty estimate was 12% for the total removals by forest land remaining forest land. Uncertainty estimates regarding the major parameters in this category are shown in Table 6-18.

Table 6-18 Uncertainty estimates regarding major parameters in the forest land category

			Uncertainty Estimates [%]	Country Specific (CS) or Default(D)	Remarks
Forest land area			5.9	CS	Estimated based on uncertainty estimates of land areas in the NFRDB. Used 5.9% without distinguishing tree species.
Volume of timber per area			22	CS	Estimated based on analysis of comparison between yield table and measured data
Biomass Expansion Factor	Japanese cedar	≦20	3.5	CS	Estimated based on measured values
		＞20	1.1	CS	
	Hinoki cypress	≦20	3.2	CS	
		＞20	1.6	CS	
	Oak (deciduous tree)	≦20	8.6	CS	
		＞20	2.1	CS	
Wood density	Japanese cedar		2.5	CS	
	Hinoki cypress		1.7	CS	
	Oak (deciduous tree)		1.6	CS	
Carbon fraction of dry matter	All tree species		6.0	D	Estimated taking into account the 2006 IPCC Guidelines default value.
Dead wood	All forests		22.1	CS	Result of uncertainty analysis of CENTURY-jfos model.
Litter			51.0		
Soils			19.9		

- ***Time-series Consistency***

There were no data for forest areas for FY1991 to FY1994, FY1996 to FY2001, and FY2003 to FY2004. Therefore, the time-series consistency was ensured by estimating these forest areas by means of interpolation.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of the intensively managed forests in forest land remaining forest land are estimated by deducting land converted to forest land from total area of intensively managed forests. Areas of intensively manages forests in forest land remaining forest land was recalculated because areas of afforestation and reforestation (AR areas), which is used as original data for determining areas of

forests converted from other land-use, were revised from FY2008 to FY2013. Following the revision, carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were recalculated. For details in the revision of estimation method of AR and D areas, please see the Chapter 11, 11.5.1.6, "Review of AR and D areas". For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

None.

6.5.2. Land converted to Forest land (4.A.2)

a) Category Description

This subcategory deals with the carbon stock changes in forest land converted from other land-use categories within 20 years. The net removal by this subcategory in FY2014 was 338 kt-CO_2. This represents a decrease of 83.7% below the FY1990 value and a decrease of 6.5% below the FY2013 value. Removals since 1990 have been in consistent decreasing trend. The reason of the consistent decrease trend is inferred that the number of proprietors of forestry business who newly expand their areas for planting trees has decreased because profitability of forestry business in Japan has declined.

b) Methodological Issues

1） Carbon stock change in Living Biomass in "Land converted to Forest land"

- ***Estimation Method***

In the Tier 2 method, the annual carbon stock change in land converted to forest land (ΔC_{LF}) is to be estimated by summing the loss of carbon stock due to conversion (ΔC_L) and the change of carbon stock accumulated after conversion (ΔC_F). However, it is difficult to extract removals occurred on land converted to forest land directly from the data of the NFRDB because it deals with the stock change of living biomass of both forest land remaining forest land and land converted to forest land after land conversion collectively. On the other hand, it can be assumed that forest land subjected to AR activities under Article 3, paragraph 3, of the Kyoto Protocol and land converted to forest land have similar nature. Therefore, ΔC_F was estimated by multiplying the area of converted land by the carbon stock change per unit area due to AR activities. The ΔC_F value is reported all together under rice field converted to forest land in the CRF. ΔC_L was estimated and reported for each land-use category. For conversions from rice field, upland field, wetlands, settlements and other land, where carbon stocks of living biomass are assumed as 0, the carbon losses are reported as "NA".

$$\Delta C_{LF} = \Delta C_L + \Delta C_F$$

$$\Delta C_L = \sum_i \left\{ A_i \times (B_a - B_{b,i}) \times CF \right\}$$

$$\Delta C_F = A_{LF} \times IEF_{AR}$$

ΔC_{LF} : Annual carbon stock change in land converted to forest land [t-C/yr]
ΔC_L : Annual carbon stock change at the land conversion [t-C/yr]
ΔC_F : Carbon stock change in the converted land within 20 years since conversion [t-C/yr]
i : Land–use category before conversion

A_i : Annual increase of land area that has been converted from land-use type i to forest [ha/yr]
B_a : Dry matter weight per unit area immediately after conversion to forest [t-C/yr]
$B_{b,i}$: Dry matter weight per unit area before conversion from land-use type i to forest [t-C/yr]
A_{LF} : Area of converted forest land within 20 years [ha]
IEF_{AR} : Average carbon stock change per unit area due to AR activities (equal to the implied removal factor) [t-C/ha/yr]
CF : Carbon fraction of dry matter [t-C/t-d.m.]

- ***Parameters***

➢ ***Per unit area removals of Afforestation and Reforestation activities***

The average value of carbon stock change per unit area due to AR activities between FY2008 and FY2010 (2.9 t-C/ha) was applied to all reporting years.

➢ ***Biomass stock in each Land-Use Category***

The parameter of grassland before conversion, shown in Table 6-8a, is used.

- ***Activity Data (Area)***

The areas of land converted to forest land within 20 years were calculated by summing the annually converted areas during the past 20 years. The estimation methods for annually converted areas from each land-use category are described below.

➢ ***Total area of "Land converted to Forest land"***

It is logically presumed that the areas of land converted to forest land include AR areas, forest land restored from degraded land by natural succession, and land whose land-use categories are changed to forest land due to other reasons. However it does not occur in general in Japan that forest land restored from degraded land by natural succession would be determined as "Forests under Forest Law Article 5 and 7.2" as indicated in Table 6-2. Therefore, such areas are classified as remaining land categories. Hence, it is regarded that the areas of land converted to forest land are similar to the AR areas, and that the areas are determined in accordance with the concept of "overlap" described as a time series consistency and recalculation approach on section 5.3.3.1 in Volume 1 of the *2006 IPCC Guidelines*, by using the AR areas and areas of forested cropland reported in the *Statistics of Cultivated and Planted Area*. In concrete terms, the AR areas are identified in detail by utilizing orthophotos taken at the end of 1989 and recent satellite images, but they are provided only from the FY2005 values. Therefore, the areas of land converted to forest land are estimated by setting an adjustment factor from the ratio between the AR areas since FY2005 and areas of forested cropland provided by the *Statistics of Cultivated and Planted Area*, and multiplying the areas of forested cropland since FY1990 by the adjustment factor. The areas of land converted to forest land in and after 2006 were regarded as the same as the areas obtained by utilizing the method of estimating AR areas in KP-LULUCF. For further information on determining AR areas, see section 11.4.2.3 in Chapter 11.

➢ ***Areas of "Cropland and Grassland converted to Forest Land"***

The areas of cropland converted to forest land before FY2005 were determined by utilizing the areas of forested cropland reported in the *Statistics of Cultivated and Planted Area*. As its subcategories, the areas of cropland converted to forest land are categorized to rice fields converted to forest land, upland fields converted to forest land and orchards converted to forest land. The areas of rice fields converted to forest land are determined by utilizing the areas of forested by planting on rice fields

provided by the *Statistics of Cultivated and Planted Area*. The areas of upland fields and orchards converted to forest land are estimated by dividing the areas of forested by planting on arable land, also provided by the *Statistics of Cultivated and Planted Area*, by means of the existing area ratios of upland fields, orchards and pasture land.

The areas of grassland converted to forest land are calculated by summing the areas of forested by planting on pasture land estimated from the data in the *Statistics of Cultivated and Planted Area* and those of forested by planting on grazed meadow reported in *A Move and Conversion of Cropland*.

The areas of cropland or grassland converted to forest land since 2006 were respectively estimated by multiplying the percentage of the number of plots interpreted as conversion from cropland or grassland to forest land in the total number of AR plots, by the total AR area obtained by utilizing the method of estimating AR areas in KP-LULUCF.

- ***Areas of "Wetlands, Settlements or Other land converted to Forest land"***

The areas of wetlands, settlements, and other land converted to forest land cannot be obtained directly from statistics for the years before FY2005. Therefore, they are estimated by subtracting the summed areas of cropland converted to forest land and grassland converted to forest land from the total area of land converted to forest land, and by multiplying the difference by ratios of areas of wetlands, settlements, and other land converted to forest land, which are estimated based on trend of results of AR identification.

The areas of wetlands, settlements or other land converted to forest land since FY2006 were respectively estimated by multiplying the percentage of the number of plots interpreted as conversion from wetlands, settlements or other land to forest land in the total number of AR plots, by the total AR area obtained by utilizing the method of estimating AR areas in KP-LULUCF.

Table 6-19 Area of land converted to forest land (single year)

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Forest land	kha	3.48	1.57	1.39	0.76	0.45	1.02	3.19	1.07	2.67	0.34	0.78	0.08	0.13
Cropland converted to Forest land	kha	2.71	1.22	1.08	0.57	0.24	0.57	1.67	0.59	1.40	0.19	0.41	0.04	0.07
Rice field	kha	0.92	0.47	0.41	0.17	0.07	0.18	0.55	0.19	0.48	0.05	0.12	0.01	0.02
Upland field	kha	1.31	0.57	0.51	0.31	0.13	0.30	0.88	0.31	0.73	0.11	0.23	0.02	0.04
Orchard	kha	0.49	0.19	0.15	0.09	0.04	0.08	0.24	0.08	0.19	0.03	0.06	0.01	0.01
Grassland converted to Forest land	kha	0.67	0.31	0.28	0.17	0.03	0.12	0.22	0.13	0.18	0.04	0.06	0.01	0.01
Wetlands converted to Forest land	kha	NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Settlements converted to Forest land	kha	0.05	0.02	0.02	0.01	0.12	0.24	0.82	0.25	0.69	0.08	0.20	0.02	0.03
Other land converted to Forest land	kha	0.05	0.02	0.02	0.01	0.07	0.09	0.48	0.09	0.39	0.03	0.11	0.01	0.02

(Reference): Forestry Status Survey, National Forest Resources Database (Forestry Agency)

Table 6-20 Area of Land converted to forest land within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Forest land	kha	143.5	71.1	51.1	38.4	36.1	34.7	35.4	31.5	30.7	28.0	26.6	24.8	23.2
Cropland converted to Forest land	kha	121.9	57.7	40.6	30.0	28.1	26.6	26.3	23.1	21.8	19.7	18.3	16.9	15.6
Rice field	kha	53.8	23.7	15.9	11.0	10.2	9.5	9.3	8.6	8.2	7.4	6.8	6.2	5.7
Upland field	kha	46.8	23.7	17.7	14.0	13.2	12.7	12.8	11.0	10.4	9.4	8.9	8.3	7.7
Orchard	kha	21.4	10.3	6.9	4.9	4.6	4.4	4.3	3.6	3.3	2.9	2.7	2.4	2.2
Grassland converted to Forest land	kha	19.3	11.6	9.0	7.3	6.9	6.6	6.4	5.5	5.0	4.5	4.1	3.8	3.5
Wetlands converted to Forest land	kha	NO	NO	NO	NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Settlements converted to Forest land	kha	1.2	0.9	0.7	0.5	0.6	0.8	1.6	1.8	2.4	2.5	2.6	2.6	2.6
Other land converted to Forest land	kha	1.2	0.9	0.7	0.5	0.6	0.6	1.1	1.1	1.4	1.4	1.5	1.5	1.5

2） Carbon Stock Changes in Dead Organic Matter and Soils in "Land converted to Forest land"

- ***Estimation Method***

Carbon stock changes in dead wood, litter and mineral soils were calculated under the assumption that these carbon stocks change linearly over 20 years from those in land-use categories other than forest land to those in forest land. The calculation was implemented by applying the average carbon stocks obtained by the CENTURY-jfos model. Emissions from organic soils in this category were reported as "NO" in the same manner as forest land remaining forest land.

$$\Delta C_{LF,i} = A_i \times (C_{after} - C_{before,i}) / 20$$

$\Delta C_{LF,i}$: annual change in carbon stocks in dead wood, litter or soils in land-use category *i* converted to forest land [t-C/yr]
A_i : area of land-use category *i* being converted to forest land within the past 20 years [ha]
C_{after} : average carbon stocks per unit area in land-use category after conversion (forests) [t-C/ha]
$C_{before,i}$: average carbon stocks per unit area in land-use category *i* before conversion [t-C/ha]
i : land-use category (cropland, grassland, wetlands, settlements, or other land)

- ***Parameters***

Parameters for each carbon pool in Table 6-9 (dead wood), Table 6-10(litter) and Table 6-11 (soil) were used, in particular, for the categories cropland, grassland, wetlands, settlements and other land before conversion and for the category forest land after conversion.

- ***Activity Data (Area)***

➢ ***Total areas of "Land converted to Forest land"***

See Table 6-20.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of the parameters and activity data for living biomass, dead organic matter, and soil were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. As a result, the uncertainty estimate was 12% for the entire removal by land converted to forest land.

- ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

As it was mentioned in 6.5.1.e), areas of forest land converted from other land-use categories was revised. Accordingly, stocking volume of afforestation and reforestation (AR areas) and carbon stock

changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were recalculated. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Carbon Stock Changes in Soils in "Cropland and Grassland converted to Forest Land"***

The areas converted to forest land from upland fields, orchards and pasture land are estimated by multiplying the total areas converted from cropland to forest land by each area ratio of upland fields, orchards and pasture land. However, this estimation method may not represent the true status of these areas. Hence, improvement of the validity of the estimation method and land-area identification is an issue to be examined in the future.

6.6. Cropland (4.B)

Cropland is the land that produces annual and perennial crops; it includes temporarily fallow land. Cropland in Japan's inventory consists of rice fields, upland fields, orchards and cultivation abandoned agricultural land.

In FY2014, Japan's cropland area was about 4.31 million ha, which is equivalent to about 11.4% of the national land. The area of organic soil in cropland is about 0.18 million ha. The emissions from this category in FY2014 were 4,496 kt-CO_2 (excluding 34.8 kt-CO_2 eq. of non-CO_2 emissions from drained organic soils and drainage ditches, 8.8 kt-CO_2 eq. of N_2O emissions resulting from nitrogen mineralization resulting from change of land use or management of mineral soils, and 21.6 kt-CO_2 eq. of CH_4 and N_2O emissions resulting from biomass burning); this represents a decrease of 62.9% below the FY1990 value and an increase of 23.6% over the FY2013 value.

This section divides cropland into two subcategories, "Cropland remaining Cropland (4.B.1.)" and "Land converted to Cropland (4.B.2.)", and describes them separately in the following subsections.

Table 6-21 Emissions and removals in cropland resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.B. Cropland	Total	kt-CO_2	12,107	5,584	200	2,291	1,514	4,861	10,309	7,917	5,455	5,690	4,780	3,639	4,496
		Living Biomass	kt-CO_2	1,657	528	245	287	287	214	274	342	355	249	261	237	279
		Dead Wood	kt-CO_2	405	82	26	48	48	25	35	43	85	33	37	29	43
		Litter	kt-CO_2	194	40	13	23	23	12	17	21	41	16	18	14	21
		Mineral soil	kt-CO_2	8,181	3,294	-1,709	338	-433	3,024	8,402	5,934	3,399	3,843	2,912	1,806	2,603
		Organic soil	kt-CO_2	1,670	1,640	1,625	1,594	1,589	1,586	1,581	1,577	1,575	1,550	1,552	1,554	1,551
	4.B.1. Cropland remaining Cropland	Total	kt-CO_2	10,134	5,182	71	2,054	1,279	4,740	10,108	7,690	5,131	5,543	4,592	3,504	4,291
		Living Biomass	kt-CO_2	284	248	155	122	123	130	126	179	157	150	128	143	137
		Dead Wood	kt-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Litter	kt-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Mineral soil	kt-CO_2	8,181	3,294	-1,709	338	-433	3,024	8,402	5,934	3,399	3,843	2,912	1,806	2,603
		Organic soil	kt-CO_2	1,670	1,640	1,625	1,594	1,589	1,586	1,581	1,577	1,575	1,550	1,552	1,554	1,551
	4.B.2. Land converted to Cropland	Total	kt-CO_2	1,973	402	129	237	235	121	200	227	324	147	189	136	205
		Living Biomass	kt-CO_2	1,373	280	90	165	164	85	148	164	198	99	134	93	141
		Dead Wood	kt-CO_2	405	82	26	48	48	25	35	43	85	33	37	29	43
		Litter	kt-CO_2	194	40	13	23	23	12	17	21	41	16	18	14	21
		Mineral soil	kt-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
		Organic soil	kt-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

6.6.1. Cropland remaining Cropland (4.B.1)

a) Category Description

This subcategory deals with carbon stock changes in cropland, which has remained as cropland during the past 20 years. The emissions from this subcategory in FY2014 were 4,291 kt-CO_2(excluding GHG emissions other than carbon stock changes); this represents a decrease of 57.7% below the FY1990 value and an increase of 22.5% over the FY2013 value.

Carbon stock changes in living biomass are estimated for the carbon stock change in perennial tree crops (fruit trees) according to the *2006 IPCC Guidelines*.

Carbon stock changes in dead organic matter are estimated as zero (0) by applying the Tier 1 method, which assumes that the carbon stocks are not changed, according to section 5.2.2.1 in Volume 4 of the *2006 IPCC Guidelines*. Thus, the carbon stock changes are reported as "NA".

Carbon stock changes in mineral soils were estimated by applying Tier 3 model (RothC, Rothamsted Carbon Model) .On-site CO_2 emissions from drained inland organic soils in rice fields and upland fields were estimated (CH_4 emission from rice cultivation is already covered in the Agriculture sector and excluded in this category). Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils in rice fields and upland fields were estimated.

CO_2 emission from organic soils in orchards and in cultivation abandoned agricultural land were reported as "NO" because tillage and drainage of organic soils in orchard was not implemented. The area of cropland remaining croplands within the past 20 years was shown in Table 6-22. In addition, this area contained that of organic soils.

Table 6-22 Areas of cropland remaining cropland within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Cropland remaining Cropland	kha	4,419	4,375	4,392	4,378	4,369	4,359	4,347	4,340	4,334	4,308	4,299	4,286	4,271
Rice fields	kha	2,602	2,590	2,555	2,513	2,503	2,494	2,484	2,478	2,472	2,453	2,448	2,443	2,435
Upland fields	kha	1,166	1,156	1,149	1,153	1,155	1,155	1,156	1,156	1,158	1,155	1,154	1,151	1,146
Orchards	kha	434	385	345	327	323	319	316	311	308	304	301	297	293
Cultivation abandonment area	kha	217	244	343	386	388	390	392	394	396	396	396	396	396

b) Methodological Issues

1） Carbon Stock Changes in Living Biomass in "Cropland remaining Cropland"

- ***Estimation Method***

Carbon stock changes in living biomass in orchards are estimated by applying the Tier 2 estimation method (the stock–difference method) described in section 5.2.1.1 in Volume 4 of the *2006 IPCC Guidelines*.

The carbon stocks in living biomass in orchards are calculated by multiplying cultivation area of each orchard tree by dry matter biomass weight per tree, planting density, and carbon fraction of dry matter. The carbon stocks in above- and below ground biomass were calculated by using the root-to-shoot ratio. These parameters except the carbon fraction are determined for each type of orchard tree.

$$\Delta C = C_2 - C_1$$

$$C = \sum_{t,j} (A_{t,j} \times D_j \times W_j) \times 10/1000 \times CF$$

C : Carbon stock change in living biomass [t-C]
A : Cultivation area of orchard [ha]
D : Planting density [tree/10a]
W : Dry matter weight of above-ground biomass per tree [kg/tree]
CF : Carbon fraction for dry matter [t-C/t-d.m.]
j : Type of orchard tree

- ***Parameters***

According to Tier 2 method described in the *2006 IPCC Guidelines*, country specific parameters of the planting density, dry matter biomass weight per tree, and root-to shoot ratio were set for major orchard trees based on existing research reports.

Dry matter biomass weight for tea tree are 48 t-d.m./ha; the dry matter biomass weight for fruit orchard tree are 8～24 t-d.m./ha, the root-shoot ratio is 7:3-5:4. The country specific carbon fraction of dry matter of forest (broad leaf : 0.48) was applied as the carbon fraction of dry matter of orchard trees.

- ***Activity Data (change of cultivation area)***

Changes of cultivation area were estimated for 15 orchard trees by each prefecture by subtracting cultivation area in the previous year from these in the current year. The cultivation area was identified by existing statistics (*Cultivated and Planted Area* by the MAFF).

2） Carbon Stock Changes in Soils in "Cropland remaining Cropland"

- ***Estimation Method***

➢ ***Carbon stock changes in mineral soils***

Carbon stock changes in mineral soils in cropland remaining cropland were estimated by applying Tier 3 model estimation method. Rothamsted Carbon Model (RothC), a simulation model for time series variation of soil carbon (t-C/ha) per unit area (100m mesh), has been applied to the estimation in cropland at national scale; the calculation by each grid of unit (100 m mesh), has carried out until now, corresponding to default value, soil property, annual land use, climate, and agricultural activities (amount of carbon input).

Soil carbon per unit area (t-C/ha) by each grid has been yearly calculated; the change from the previous year represents carbon stock changes (t-C/ha/year) per unit square in the year.

The carbon stock changes (t-C/year) were calculated by multiplying the average carbon stock changes in each year by land use subcategory (rice fields, upland fields and orchards), by areas of land provided in the existing inventory report based on statistics. CO_2 emissions from mineral soil in FY2014 were 2,603 kt-CO_2; this represents a decrease of 68.2% below the FY1990 value and an increase of 44.1% over the FY2013 value. The CO_2 emissions from mineral soil has decline middle-term trend since 1990 due to the increase of carbon input into soil. While inter-annual fluctuation of carbon stock changes have occurred in response to the variation climatic condition and

the different amount of organic matter input in each year. The estimation equation is as follows:

$$\Delta C_{national} = \sum_{i,j} (\Delta SOC_{i,j} \times A_{i,j})$$

$\Delta C_{national}$: Carbon stock changes in mineral soils [t-C/yr]
SOC : Carbon stock changes in mineral soils per unit area [t-C/ha], estimated from the Roth C model
A : Area of cropland obtained from statistics [ha]
i : Prefecture
j : Type of land use subcategory in cropland

➢ ***On-site CO_2 emissions from organic soils***

On-site CO_2 emissions from organic soils in rice fields and upland fields were estimated by applying Tier 1, 2 estimation method described in section 5.2.3.1 in Volume 4 of the *2006 IPCC Guidelines*. Tier 2 method was applied to land-use subcategories for which country-specific emission factors can be used. The estimation equation is as follows:

$$\Delta C_{OS} = \sum_c (A \times EF)_c$$

ΔC_{OS} : Carbon stock changes in organic soils (emissions) [t-C/yr]
A : Area of organic soils [ha]
EF : CO_2 emission factor [t-C/ha/yr]
c : Climate zone

➢ ***Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils***

Off- site CO_2 emissions via waterborne carbon losses from drained inland organic soils in rice fields and upland fields were estimated by applying Tier 1 estimation method described in the *Wetlands guidelines*. The estimation equation is as follows:

$$CO_2 - C_{DOC} = \sum (A \times EF_{DOC})$$

$$EF_{DOC} = DOC_{FLUX\_NATURAL} \times (1 + \Delta DOC_{DRAINAGE}) \times F_{rac_{DOC-CO2}}$$

CO_2-C_{DOC} : Annual off-site CO_2-C emissions due to DOC loss from drained organic soils [t-C/yr]
A : Land area of drained organic soils in land-use subcategory [ha]
EF_{DOC} : Emission factors for annual CO_2 emissions doe to DOC loss from drained organic soils [t-C/ha/yr]
$DOC_{FLUX\_NATURAL}$: Flux of DOC from natural (undrained) organic soil [t-C/ha/yr]
$\Delta DOC_{DRAINAGE}$: Proportional increase in DOC flux from drained sites relative to undrained sites
$Frac_{DOC\text{-}CO2}$: Conversion factor for proportion of DOC converted to CO_2 following export from site

● ***Parameters***

➢ ***Assumption and parameters necessary for mineral soil modeling***

RothC, the Soil carbon dynamic model, calculates the amount of soil carbon; input parameters are climate data, soils, and carbon input. The verification of RothC had been performed in agricultural fields where the above parameters were available, based on actual measured data; the model with

improved accuracy in estimating carbon soil in Japanese cropland has been developed. To apply the model to nation-wide estimation, input data was organized using the existing statistical material and map data: 1km mesh for climate, 100m mesh for soil and land use, and amount of carbon input was adjusted by prefecture and by land use subcategory.

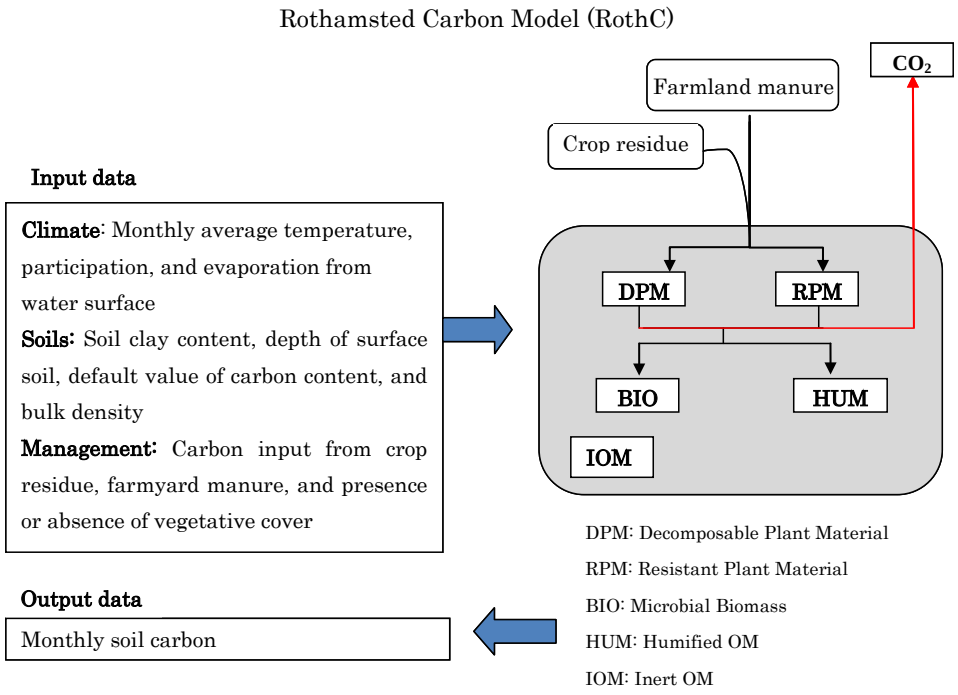

Figure 6-3 RothC model

CO_2 emissions and removals from mineral soils will be estimated by applying the model to national cropland and calculating changes of soil carbon over time.

➢ *CO_2 emission factors from organic soils (on-site)*

The following CO_2 emission factors from organic soils in rice fields and upland fields were applied to the estimation.

Table 6-23 CO_2 emission factors resulting from cultivation of organic soils

Type of land use	Climate zone	Emission factors [t-C/ha/yr]	Reference
Rice field	Cold temperate	1.55	Measured data[1)]
	Warm temperate	1.55	Data measured for cold temperate was applied.[2)]
Upland field	Cold temperate	4.18	Measured data
	Warm temperate	10.0	Default value (2006 IPCC Guidelines, Table 5.6)

1) Measured data of rice field was set as if emission in waterlogging period was zero (0).

2) The emission factor of rice field in warm temperate was excluded in default values in *the 2006 IPCC Guidelines*; hence, the country-specific factor in cold temperate was applied as substitute.

➢ *CO_2 emissions factors from organic soils (off-site)*

Tier 1 default parameters described in the *Wetlands guidelines* were applied to the estimation.

Table 6-24 Default DOC emission factors for drained organic soils

Climate zone	$DOC_{FLUX\_NATURAL}$ [t-C/ha/yr]	$DOC_{DRAINAGE}$	$Frac_{DOC-CO2}$	EF_{DOC} [t-C/ha/yr]
Temperate	0.21	0.60	0.9	0.31

The Wetlands guidelines: Table 2.2

- ***Activity Data (Area)***

➢ ***Area of mineral soils***

Areas of mineral soils in cropland remaining cropland were estimated by subtracting areas of organic soils in cropland (Table 6-25) from area of cropland remaining cropland within 20 years estimated by applying areas reported in the *Statistics of Cultivated and Planted Area* (Table 6-22).

➢ ***Area of organic soils***

Information on areas of organic soils in agricultural land in 1992 and 2001 was understood. Hence, areas of organic soils in each year were estimated by multiplying the following ratio estimated by the information to the total cropland area:

- In and before FY1992: ratio of organic soil area in FY1992,
- From FY1993 to FY2000: ratio of organic soil area estimated by interpolating the numbers between FY1992 and FY2001,
- In and after 2001: ratio of organic soil area in FY2001.

In this estimation, areas of each prefecture were estimated separately. The areas of organic soils in Japan by estimating the method mentioned above are as follows:

Table 6-25 Areas of organic soils in cultivated cropland

Category			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total			kha	190.0	187.2	185.8	181.3	180.5	180.0	179.4	178.9	178.6	175.5	175.9	176.2	175.9
	Rice field		kha	163.4	161.8	160.7	156.4	155.6	155.0	154.4	154.0	153.7	150.8	151.1	151.4	151.3
		Hokkaido	kha	48.5	48.8	49.4	48.2	48.0	47.8	47.7	47.6	47.5	47.5	47.4	47.4	47.3
		Other than Hokkaido	kha	114.9	113.0	111.3	108.2	107.6	107.2	106.7	106.4	106.1	103.3	103.7	104.1	104.0
	Upland field		kha	25.1	24.2	24.1	24.1	24.1	24.1	24.2	24.1	24.1	24.0	24.0	24.0	23.9
		Hokkaido	kha	18.2	17.5	17.7	17.7	17.7	17.8	17.8	17.8	17.8	17.8	17.8	17.8	17.8
		Other than Hokkaido	kha	6.9	6.7	6.4	6.4	6.4	6.4	6.4	6.3	6.3	6.2	6.2	6.2	6.1
	Orchard		kha	1.5	1.1	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7
		Hokkaido	kha	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		Other than Hokkaido	kha	1.4	1.1	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Note: Hokkaido is classified as Cold temperature; other areas except for Hokkaido is classified as Warm temperature.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

For the parameters and the activity data in biomass in orchard, the uncertainties of existing statistics and the default values described in the *2006 IPCC Guidelines* were applied. For the uncertainties of mineral soil, the comparison of simulation results and current measurement, when both input values and current measurement values of mineral soils are available, revealed that the uncertainty due to model structure was estimated about 10%. The uncertainty caused by input values has not been quantified yet and remains as an issue to be solved. For the uncertainties of organic soil, the uncertainties of statistical data and default values given in the *2006 IPCC Guidelines* are used. As a result, the uncertainty was estimated as 33% for the entire emission from the cropland remaining cropland.

- ***Time-series Consistency***

Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of cropland remaining cropland were estimated by subtracting areas of land converted to cropland from the total cropland areas. Areas of cropland converted from forest land were revised due to revision of areas of deforestation (D area), which was used as original data for determining each land use area converted from forest land, in FY2008, FY2010 and FY2012. As a result, areas of cropland remaining cropland and emissions in organic soils were also recalculated (FY2008-2013). For more details on correction of estimation methodology of areas of deforestation, please see Chapter 11, 11.5.1.6 in NIR "Review of AR areas and D areas". For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Carbon Stock Changes in Mineral Soils in "Cropland remaining Cropland"***

Further improvement in method of the carbon-stock changes estimation in mineral soils is planned in the future.

6.6.2. Land converted to Cropland (4.B.2)

a) Category Description

This subcategory deals with the carbon stock changes which occurred in the lands that were converted from other land use categories to cropland within the past 20 years. Total area of land converted to cropland within the past 20 years by FY2014 is 34.6kha, which represents 0.1% of the national total area.

The emissions from this subcategory in FY2014 were 205 kt-CO_2 (excluding GHG emissions other than carbon stock changers); this represents a decrease of 89.6% below the FY1990 value and an increase of 51.1% over the FY 2013 value. Emissions from land converted to cropland are on a decreasing trend because of a decreasing trend of areas of land converted to cropland, but those in FY2009 increased over FY2008. In 2009, areas of forest land, in which carbon stocks were higher than other land-use categories, converted to cropland increased compared with FY2008; hence, emissions higher than those in 2008 were reported in 2009.

With respect to living biomass, its carbon stock change as a result of land-use conversion from other land use to cropland is estimated. This process includes both temporary loss of living biomass in the land before and subsequent gain of living biomass after conversion. However, gains in carbon stocks in rice fields land and upland fields were set as zero. Gains in carbon stocks in orchard were estimated in cropland remaining cropland in a lump and was reported as "IE".

With respect to dead organic matter, Japan used the CENTURY-jfos model to estimate carbon stocks

in dead organic matter in forest land, and then estimated carbon stock changes in forest land converted to cropland. Carbon stock changes in cropland converted from land-uses other than forest land were reported as "NA" assuming that the emissions would not occur.

In regard to carbon stock changes in mineral soils, the carbon stock changes in cropland converted from forest land, grassland and wetlands were estimated in the tier 3 model in a lump for the whole cropland area, and so reported as "IE". CO_2 emissions from organic soils in cropland converted from land-use categories were reported as "IE" because the emissions were estimated and reported in those in cropland remaining cropland in a lump.

b) Methodological Issues

1） Carbon stock changes in Living Biomass in "Land converted to Cropland"

- ***Estimation Method***

The Tier 2 method is applied for forest land converted to cropland using the country specific value of the amount of biomass accumulation. The Tier 1 method is applied for land uses other than forest land converted to cropland using provisional and default values.

$$\Delta C = \Delta C_i + \Delta C_j$$

$$\Delta C_i = A \cdot (CR_a - CR_i) \times CF$$

$$\Delta C_j = A \times CR_j \times CF$$

ΔC : annual carbon stock change in the converted land [t-C/yr]
ΔC_i : annual carbon stock change at the time of land conversion [t-C/yr]
ΔC_j : annual carbon stock change in the converted land after conversion [t-C/yr]
i : land use before conversion
j : land use after conversion
A : area of converted land for the current year [ha]
CR_a : dry matter biomass weight per unit area immediately following conversion [t-d.m./ha/yr], default value=0
CR_i : dry matter biomass weight per unit area before land was converted from land-use type *i* [t-d.m./ha/yr]
CR_j : change of dry matter biomass weight per unit area accumulated after conversion [t-d.m./ha/yr]
CF : carbon fraction of dry matter [t-C/t-d.m.]

- ***Parameters***

➢ ***Biomass stock in each Land-Use Category***

The values shown in Table 6-8a and Table 6-8b are used for the estimation of biomass stock changes upon land-use conversion and subsequent changes in biomass stock due to biomass growth in the converted land.

➢ ***Carbon Fraction of Dry Matter***

Average value of broad leaf trees and conifer trees (0.50t-C/t-d.m.) was applied as the carbon fraction of dry matter of forest. The default value (0.5 t-C/t-d.m.) was applied for other than forest.

- ***Activity Data (Area)***

➢ ***Areas of forest land converted to other land-use categories***

It was assumed that the areas of forest land converted to other land-use categories (cropland, grassland, wetlands, settlement and other land) were consistent with the area of deforestation (D area) reported under Article 3, paragraph 3, of the Kyoto Protocol. Thus, the area of forest land converted to cropland was estimated by allocating the D area. Since the D survey has been conducted since FY2005, the applied method to calculate the D area for FY1990 to FY2004 and for post FY2005 are as follows, respectively.

- ***From FY1990 to FY2004***

In the period from 1990 to 2004, annual conversion areas from forest land to other land-use categories were identified by surveys on D areas. With respect to the areas before 1989, the areas were obtained from statistics provided by the *World Census of Agriculture and Forestry* and the Forestry Agency's records, but the areas obtained from the surveys on D areas were larger than those from statistics. Hence, the total areas converted from forest land are estimated by setting an adjustment factor from the ratio between the D areas since FY1990 and the areas converted from forests provided by the *World Census of Agriculture and Forestry* and the Forestry Agency's records, and multiplying the areas converted from forests since FY1970 by the adjustment factor. For further information on determining the D areas, see section 11.4.2.3 in Chapter 11.

The areas of forest land converted to each land-use category are estimated by setting ratios of conversion from areas of private forests converted to other land-use categories resulting from forest land development, based on the Forestry Agency's records, and by multiplying the total conversion areas from forest land by the ratios of conversion. The ratios are regarded as applicable to the total forests because conversion from private forests to other land-use categories accounts for 90% of the total areas of conversion from forest land.

- ***After FY2005***

The areas of forest land converted to cropland, grassland, wetlands, settlements and other land were estimated by multiplying the D area by the land ratios of forest land converted to each land-use category. Both the ratio and the area were determined by the D survey.

➢ ***Areas of conversion from land-use categories other than forest land***

The areas of land converted from land-use categories other than forest land to cropland are determined by applying expansion area values provided by the *Statistics of Cultivated and Planted Area*. The converted areas from arable land are divided into upland fields, orchards, and pasture land proportionately by means of the current area ratios. The areas of rice fields, upland fields, and orchards are allocated to cropland, while the area of pasture land is allocated to grassland. In addition, settlements converted to cropland are reported as "IE" because the areas are included in other land remaining other land.

It should be noted that the area presented in the CRF "Table 4.B Sectoral background data for land use, land-use change and forestry－Cropland" is not the annually converted area in FY2014 but the sum of annually converted areas during the past 20 years.

Table 6-26 Area of land converted to cropland (single year)

Category			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Cropland			kha	7.9	2.6	1.9	1.3	2.6	1.0	1.2	0.8	1.6	0.7	4.5	4.5	3.8
	Forest land converted to Cropland		kha	7.3	1.5	0.5	0.9	0.9	0.5	0.6	0.8	1.5	0.6	0.7	0.5	0.8
		Rice field	kha	0.01	0.02	0.003	0.001	0.02	0.02	0.06	0.03	0.13	0.06	0.10	0.14	0.32
		Upland field	kha	7.31	1.47	0.48	0.88	0.85	0.44	0.58	0.75	1.41	0.53	0.58	0.38	0.46
		Orchard	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Grassland converted to Cropland		kha	0.00197	0.02	0.0124	0.0273	0.0107	0.0044	0.0047	0.0042	0.0003	0.0009	0.0007	0.0007	0.0031
	Wetlands converted to Cropland		kha	0.33667	0.03221	0.07337	NO	NO	NO	0.47431	NO	NO	NO	NO	NO	NO
	Settlements converted to Cropland		kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Other land converted to Cropland		kha	0.21490	1.07	1.34	0.36	1.76	0.58	0.11	0.05	0.04	0.11	3.79	4.03	3.06
		Rice field	kha	0.19300	1.04	1.32	0.26	1.66	0.57	0.10	0.05	0.03	0.11	3.67	3.67	2.73
		Upland field	kha	0.02190	0.03	0.02	0.10	0.10	0.01	0.01	0.001	0.01	0.01	0.12	0.36	0.33
		Orchard	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

2） Carbon Stock Change in Dead Organic Matter in "Land converted to Cropland"

- ***Estimation Method***

Carbon stock changes in dead organic matter in forest land converted to cropland were estimated by applying Tier 2 estimation method using the value of carbon stock in dead organic matter in forest land obtained by the CENTURY-jfos model. All carbon stocks in dead organic matter in the subcategory are assumed oxidized and emitted as CO_2 within the year of conversion in accordance with the description in section 5.3.2.1 in the *2006 IPCC Guidelines*. In addition, as described in the Parameters section below, carbon stocks of dead organic matter in cropland are assumed to be zero.

$$\Delta C_{DOM} = \sum_i \left\{ (C_{after,i} - C_{before,i}) \times A \right\}$$

ΔC_{DOM} : Carbon stock changes in dead organic matter in the converted land [t-C/yr]

$C_{after,i}$: Average carbon stock per unit area in dead wood or litter after conversion [t-C/ha]
Note: carbon stocks after conversion are assumed as "0" (zero).

$C_{before,i}$: Average carbon stock per unit area in dead wood or litter before conversion [t-C/ha]

A : Area of converted land within the year of conversion [ha]

i : type of dead organic matter (dead wood or litter)

With regard to grassland converted to cropland, carbon stocks of dead wood and litter carbon pools were assumed to be minor and the stock changes could be ignored, and were thus reported as "NA". With regard to wetlands and settlements converted to cropland, these were also reported as "NA", since carbon stock changes were assumed as zero to zero, supposing that basically no such carbon pools exist in reclaimed wetland and that carbon stocks of dead organic matter in settlements before conversion were assumed as negligible. Other land converted to cropland, which is estimated to be cropland restoration, was reported as "NA", because dead wood and litter in non-forest land are assumed as zero based on the Tier 1 method described in the *2006 IPCC Guidelines*.

- ***Parameters***

Average carbon stocks in dead wood and litter in forest land before conversion are shown in Table 6-9 and Table 6-10. In addition, it is assumed that they become zero immediately after conversion, and will not accumulate after conversion.

- ***Activity Data (Area)***

Annually converted areas to cropland are used for estimating carbon stock changes in dead organic matter in land converted to cropland.

3） Carbon Stock Changes in Soils in "Land converted to Cropland"

- ***Estimation Method***

As for mineral soil, soil carbon was estimated by using Tier 3 modeling method same as 6.6.1.b) 2) cropland remaining cropland. For the estimation, land unit which was recorded once as cropland since 1970's was regarded as cropland and used for calculation; the result of the calculation includes all croplands, regardless of whether or not land conversion. Therefore, carbon stock in mineral soil was reported regardless of whether or not land conversion has been occurred and carbon stock in cropland converted from other land use was reported as "IE" since it was included in carbon stock in cropland remaining cropland. CO_2 emission from organic soils was estimated in cropland remaining cropland in a lump and was reported as "IE" for land converted to cropland. See section 6.6.1.b)2) for details. The areas of land converted to cropland are shown in Table 6-27 below.

Table 6-27 Area of land converted to cropland within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Cropland	kha	394.2	246.9	136.5	68.6	63.1	56.9	51.6	43.8	37.5	33.6	33.2	35.5	35.8
Forest land converted to Cropland	kha	279.7	204.0	121.8	56.2	49.3	42.9	37.3	30.0	24.2	20.7	16.9	15.8	15.1
Rice field	kha	17.8	11.7	1.0	0.5	0.5	0.4	0.5	0.4	0.6	0.6	0.6	0.7	0.9
Upland field	kha	261.9	192.3	120.8	55.7	48.8	42.5	36.9	29.5	23.6	20.1	16.2	15.1	14.2
Orchard	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Grassland converted to Cropland	kha	8.6	4.8	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.3	0.2
Wetlands converted to Cropland	kha	11.9	3.9	2.0	1.2	1.0	0.9	1.2	1.1	0.7	0.7	0.6	0.6	0.6
Settlements converted to Cropland	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to Cropland	kha	94.1	34.2	12.0	10.8	12.2	12.6	12.5	12.3	12.1	11.7	15.2	18.7	19.9
Rice field	kha	21.8	12.6	10.7	9.4	10.8	11.1	11.1	11.0	10.8	10.4	13.8	17.1	18.2
Upland field	kha	72.3	21.7	1.4	1.4	1.5	1.5	1.4	1.4	1.4	1.3	1.4	1.6	1.7
Orchard	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

Uncertainties of the parameters and the activity data for living biomass, dead organic matter were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty was estimated as 18% for the entire emission from the land converted to cropland.

- ***Time-series Consistency***

Although the methods to estimate the area of forest land converted to other land-use categories are different between FY1990-2004 and post FY2005 as described in section 6.6.2.b)1), time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of cropland converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in

living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated. For the impact of the recalculation, refer to Chapter 10.

f) Source-/Sink-specific Planned Improvements

- ***Methods of Obtaining Data of the area of "Grassland converted to Cropland"***

Data on the area of land converted from grassland to cropland other than land converted from grassland (pasture land) to cropland (rice field) cannot be obtained from currently available statistics, so the carbon stock changes in these areas have not been estimated. Therefore, the methods of obtaining the following area data of conversion need to be investigated.

- from pasture land to upland field
- from pasture land to orchard
- from grazed meadow to rice field
- from grazed meadow to upland field
- from grazed meadow to orchard

- ***Estimation Method of Soil Carbon Stock Change upon "Land converted to Cropland"***

The estimation method will be considered when new data and information are obtained.

6.7. Grassland (4.C)

Grassland is generally covered with perennial pasture and is used mainly for harvesting fodder or grazing. In FY2014, Japan's grassland area was about 0.95 million ha, which is equivalent to about 2.5% of the national land. The area of organic soil in the grassland is about 0.056 million ha. The carbon stock changes in this category in FY1990 was 1,111 kt-CO_2 emissions, 240.7 kt-CO_2 removals in FY2013, and 68.4 kt-CO_2 removals in FY2014 (excluding 2.2 kt-CO_2 eq. of non-CO_2 emissions from drained organic soils and drainage ditches, 4.3 kt-CO_2 eq. of N_2O emissions resulting from nitrogen mineralization resulting from change of land use or management of mineral soils) .

This section divides grassland into two subcategories, "Grassland remaining Grassland (4.C.1.)" and "Land converted to Grassland (4.C.2.)", and describes them separately in the following subsections.

Table 6-28 Emissions and removals from grassland resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.C. Grassland	Total	kt-CO_2	1,111	694	43	-1,037	-482	-992	-1,342	-266	-160	163	-184	-241	-68
		Living Biomass	kt-CO_2	135	14	-12	31	-9	-1	-13	41	4	23	0	29	6
		Dead Wood	kt-CO_2	57	12	4	19	8	11	6	20	14	16	6	15	7
		Litter	kt-CO_2	27	6	2	9	4	5	3	10	7	8	3	7	4
		Mineral soil	kt-CO_2	864	632	20	-1,126	-515	-1,036	-1,367	-366	-215	87	-222	-320	-113
		Organic soil	kt-CO_2	28	29	30	29	29	29	29	29	29	29	29	28	28
	4.C.1. Grassland remaining Grassland	Total	kt-CO_2	892	662	49	-1,097	-485	-1,007	-1,338	-337	-186	115	-194	-292	-85
		Living Biomass	kt-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Dead Wood	kt-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Litter	kt-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Mineral soil	kt-CO_2	864	632	20	-1,126	-515	-1,036	-1,367	-366	-215	87	-222	-320	-113
		Organic soil	kt-CO_2	28	29	30	29	29	29	29	29	29	29	29	28	28
	4.C.2. Land converted to Grassland	Total	kt-CO_2	219	33	-6	60	3	15	-4	71	26	48	10	51	17
		Living Biomass	kt-CO_2	135	14	-12	31	-9	-1	-13	41	4	23	0	29	6
		Dead Wood	kt-CO_2	57	12	4	19	8	11	6	20	14	16	6	15	7
		Litter	kt-CO_2	27	6	2	9	4	5	3	10	7	8	3	7	4
		Mineral soil	kt-CO_2	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO
		Organic soil	kt-CO_2	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO

6.7.1. Grassland remaining Grassland (4.C.1)

a) Category Description

In this category carbon stock changes in grassland remaining grassland during the past 20 years are reported, divided into three subcategories: “pasture land”, “grazed meadow” and “wild land”.

With respect to living biomass, carbon stock changes in pasture land and grazed meadow are assumed to be in a steady state and reported as “NA” in accordance with the Tier 1 estimation method in section 6.2.1.1 in the *2006 IPCC Guidelines*.

Carbon stock changes in dead organic matter in pasture land and grazed meadow are estimated as zero (0) by applying the Tier 1 method described in section 6.2.2.1 in the *2006 IPCC Guidelines*, which assumes that the carbon stocks are not changed. Thus, the carbon stock changes are reported as “NA”.

In regard to carbon stock changes in mineral soils, the carbon stock changes in pasture land were estimated by applying the Tier 3 method using RothC model same as cropland remaining cropland. Grazed meadows were non-degraded and sustainably managed grassland, but without significant management improvements. Therefore, the default value of the carbon stock change factor for “Nominally managed (non-degraded)” in table 6.2 of the *2006 IPCC Guidelines*, which was “1.0”, was applied to grazed meadows. In this case, soil carbon stocks were not changed over time; therefore, the soil carbon stock changes in grazed meadows were reported as “NA”. On-site CO_2 emissions resulting from tillage and drainage of organic soils and off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils in pasture land were estimated by applying Tier 1 method.

CO_2 emission from organic soils in grazed meadow was reported as “NO” because the tillage and drainage resulting from renewal of grazed meadow are not implemented.

Carbon stock changes in all carbon pools in wild land are reported as “NA” because anthropogenic management is not implemented to the wild land in general.

Table 6-29 Areas of grassland remaining grassland within the past 20 years

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Grassland remaining Grassland		kha	937.3	962.7	973.9	977.3	974.9	972.9	971.5	970.2	969.2	931.9	931.0	929.0	926.0
	Pasture land	kha	562.3	601.8	607.0	600.8	598.4	596.5	595.0	593.8	592.8	591.9	591.0	589.0	586.0
	Grazed meadow	kha	105.0	100.9	96.8	96.5	96.5	96.5	96.4	96.4	96.4	96.4	96.4	96.3	96.3
	Wild land	kha	270.0	260.0	270.0	280.0	280.0	280.0	280.0	280.0	280.0	243.6	243.6	243.7	243.7

b) Methodological Issues

1） Carbon Stock Changes in Soils in “Grassland remaining Grassland”

- ***Estimation Method***

➢ ***Carbon stock changes in mineral soils***

Carbon stock change in mineral soils in pasture land was estimated by using the Tier 3 modeling method same as 6.6.1.b)2) cropland remaining cropland (4.B.1)

➢ ***On-site CO_2 emissions resulting from cultivation in organic soils***

With respect to CO_2 emissions from organic soils in pasture land were estimated by applying the Tier 1 estimation method described in section 6.2.3.1 in the *2006 IPCC Guidelines*. The estimation method is the same as cropland remaining cropland.

➢ ***Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils***

Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils were estimated by applying Tier 1 estimation method described in section 2.2.1.2 in the *Wetlands guidelines.* The estimation method is the same as cropland remaining cropland (4.B.1).

- ***Parameters***

➢ ***Assumption for the RothC model and parameters for estimating mineral soils***

The parameters used is omitted because it is the same as cropland remaining cropland (4.B.1).

➢ ***CO_2 emission factors from organic soils (EF)***

Because there is little research data on CO_2 emission factor that is suitable for grassland in Japan, the default value provided in *the Wetlands guidelines* (Table 2.1, 6.1 t-C/ha/year) which is considered to be most appropriate for the emission factor considering distribution and management status of Japan's pasture land, was applied. As for off-site CO_2 emissions, the same parameters as cropland remaining cropland (4.B.1) were used.

- ***Activity Data***

Areas of organic soils in pasture land were obtained by applying the method same as section 6.6.1.b)2). The activity data (area) was calculated by multiplying renewal ratio (3%) of pasture land by the area of organic soils in pasture land. The renewal ratio of pasture land was set as 3% in all year based on expert judgment (See the agriculture sector for details.)

Table 6-30 Area of organic soil in grassland remaining grassland

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Grassland remaining Grassland		kha	57.4	58.6	59.3	59.4	59.2	59.0	58.8	58.6	58.5	56.7	56.6	56.4	56.2
	Pasture land	kha	39.7	41.6	42.0	41.7	41.5	41.3	41.1	40.9	40.8	40.7	40.6	40.5	40.3
	Grazed meadow	kha	4.9	4.7	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
	Wild land	kha	12.7	12.2	12.7	13.2	13.2	13.2	13.2	13.2	13.2	11.4	11.4	11.4	11.4

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

Uncertainties of carbon stock change in mineral soil are the same as cropland remaining cropland (4.B.1); therefore, the description is omitted. Uncertainties of existing statistical data and the default values described in the *Wetlands guidelines* were applied to estimate CO_2 emissions from organic soil. As a result, the uncertainty was estimated as 9% of the total emissions grassland remaining grassland.

- ***Time-series Consistency***

Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of grassland remaining grassland were estimated by subtracting areas of land converted to

grassland from the total grassland areas. Areas of grassland converted from forest land were revised due to revision of areas of deforestation (D area), which was used as original data for determining each land use area converted from forest land, in FY2008, FY2010 and FY2012. As a result, areas of grassland remaining grassland and emissions in organic soils were also recalculated (FY2008-2013). For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Carbon Stock Changes in Mineral Soils in "Grassland remaining Grassland"***

Further improvement in method of the carbon-stock changes estimation in mineral soils is planned in the future.

6.7.2. Land converted to Grassland (4.C.2)

a) Category Description

This subcategory deals with the carbon stock changes, which occurred in the lands that were converted from other land-use categories to grassland within the past 20 years. The net removal from this subcategory in FY2014 was 16.57 kt-CO_2 ; this represents a decrease of 92.4% below the FY1990 value and a decrease of 67.6% below the FY2013 value.

With respect to living biomass, its carbon stock changes as a result of land-use conversion from other land use to grassland are estimated. The carbon stock changes include both temporary loss of living biomass in the land before and subsequent gain after conversion.

With respect to dead organic matter, Japan used the CENTURY-jfos model to estimate carbon stocks in dead organic matter in forest land, and then estimated carbon stock changes in forest land converted to grassland. Carbon stock changes in grassland converted from land-uses other than forest land were reported as "NA" or "NO" because suitable knowledge for estimating carbon stocks for the land-use categories was not available, or because it was assumed that no carbon stock change occurred, respectively.

Carbon stock changes in soils as a result of land-use conversion from other land use to grassland were estimated. With respect to carbon stock changes in mineral soils, the carbon stock changes in grassland converted from forest land, cropland, wetlands and other land were estimated by using the Tier 3 model and were reported as "IE" because those were estimated in a lump and covered in grassland remaining grassland. In regard to CO_2 emissions from organic soils, CO_2 emissions from organic soils in forest land converted to grassland were reported as "NO" because conversion of organic soil area from forest land to grassland was not implemented in general in Japan. CO_2 emissions from organic soils in grassland converted from land-use other than forest land were reported as "IE" because the emissions were included in those in grassland remaining grassland.

Carbon stock changes in each carbon pool in settlements converted to grassland are reported as "NO" because the land conversion from settlements to grassland is not implemented in general in Japan.

b) Methodological Issues

1） Carbon stock changes in Living biomass in "Land converted to Grassland"

- ***Estimation Method***

The Tier 2 method was applied to estimate forest land and cropland (rice fields) converted to

grassland (pasture lands) using country specific and provisional values of the amount of biomass accumulation. The Tier 1 method was used for land uses other than forest land and cropland (rice fields) converted to grassland (pasture lands) using default value. The equations are given in section 6.6.2.b)1). While the annually converted areas were used for estimating the loss of living biomass upon land-use conversion, the biomass growth after land-use conversion was estimated by summing the converted areas for the latest five years, assuming that biomass growth reaches a steady state at a constant rate over the subsequent five years after conversion.

- ***Parameters***

➢ ***Biomass stock in each Land-Use Category***

The values shown in Table 6-8a and Table 6-8b are used for the estimation of biomass stock changes upon land-use conversion and subsequent changes in biomass stock due to biomass growth in converted land.

➢ ***Carbon Fraction of Dry Matter***

Average value of broad leaf trees and conifer trees (0.50t-C/t-d.m.) was applied as the carbon fraction of dry matter of forest. The default value (0.5 t-C/t-d.m.) was applied for other than forest.

- ***Activity Data (Area)***

As shown in Table 6-2, grassland is treated as a part of arable land in statistics of Japan. Therefore, the procedure to obtain the area of the grassland converted from other land-use categories is as described in 6.6.2.b)1). Areas of settlements converted to grassland are reported as "NO" because land conversion from settlements to grassland does not occur.

It should be noted that the area presented in the CRF "Table 4.C Sectoral background data for land use, land-use change and forestry－Grassland" is not the annually converted area in FY2014 but the sum of annually converted areas during the past 20 years.

Table 6-31 Area of land converted to grassland (single year)

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Grassland	kha	2.1	0.8	1.1	2.1	1.6	1.3	1.1	1.0	1.0	0.9	0.5	0.7	0.5
Forest land converted to Grassland	kha	1.0	0.2	0.1	0.4	0.2	0.2	0.1	0.4	0.3	0.3	0.1	0.3	0.1
Cropland converted to Grassland	kha	0.9	0.6	1.0	1.7	1.4	1.0	0.8	0.7	0.7	0.6	0.4	0.3	0.3
Wetlands converted to Grassland	kha	0.12	0.01	0.03	NO	NO	NO	0.20	NO	NO	NO	NO	NO	NO
Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other land converted to Grassland	kha	0.01	0.01	0.01	0.04	0.04	0.01	0.003	0.0003	0.004	0.003	0.05	0.15	0.14

Table 6-32 Area of land converted to grassland within the past 5 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Grassland	kha	11.8	5.6	5.3	7.1	7.6	7.8	7.8	7.1	6.0	5.3	4.6	4.1	3.7
Forest land converted to Grassland	kha	4.9	1.9	0.7	0.6	0.7	0.8	0.9	1.2	1.1	1.2	1.2	1.3	1.1
Cropland converted to Grassland	kha	6.5	3.4	4.5	6.2	6.7	6.7	6.4	5.7	4.6	3.8	3.2	2.6	2.2
Wetlands converted to Grassland		0.3	0.07	0.03	NO	NO	NO	0.2	0.2	0.2	0.2	0.2	NO	NO
Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other land converted to Grassland	kha	0.1	0.2	0.04	0.3	0.3	0.3	0.3	0.1	0.1	0.02	0.1	0.2	0.3

2） Carbon Stock Change in Dead Organic Matter in "Land converted to Grassland"

- ***Estimation Method***

In this category, carbon stock changes in dead organic matter in forest land converted to grassland

were estimated. The Tier 2 estimation method was applied to the subcategory using country specific values of the carbon stocks before and after conversion. It should be noted that the carbon stocks of dead organic matter after conversion to grassland are assumed as zero (Tier 1 method in *2006 IPCC Guidelines* Vol.4 section 6.3.2), because there are no quantitative data of them, although a subtle but certain amount of carbon stocks does generally exist on the soil surface. As described in section 6.6.2.b)2), cropland converted to grassland were reported as "NA" since the carbon stocks before and after conversion were assumed as zero. As for wetlands and other land converted to grassland, they are estimated to be reclamation and restoration. Thus they were reported as "NA"[7], for similar reasons as described in section 6.6.2.b)2).

- ***Parameters***

The average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 6-9 and 6-10. The average carbon stocks in these categories from FY1990 to FY2004 are not estimated; therefore those in FY2005 are substituted for them. In addition, it is assumed that they become zero immediately after conversion, and are not accumulated after conversion. All carbon stocks in dead organic matter in the subcategory are assumed oxidized and emitted as CO_2 within the year of conversion in accordance with the description in section 6.3.2.2 in the *2006 IPCC Guidelines*.

- ***Activity Data (Area)***

The sum of annually converted areas from other land-use categories to grassland for the past 20 years was regarded as the area of land converted to grassland during the past 20 years. The areas are shown in Table 6-33.

Table 6-33 Areas of land converted to grassland within the past 20 years

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Grassland		kha	84.3	58.9	37.7	29.8	29.0	27.5	26.3	25.0	23.9	23.3	22.3	22.1	21.8
	Forest land converted to Grassland	kha	30.7	25.5	16.7	8.1	7.2	6.5	5.8	5.0	4.3	4.0	3.4	3.5	3.4
	Cropland converted to Grassland	kha	25.2	21.2	19.8	20.7	20.8	20.1	19.4	19.0	18.8	18.5	18.0	17.7	17.5
	Wetlands converted to Grassland	kha	0.8	0.9	0.7	0.4	0.4	0.3	0.5	0.4	0.3	0.3	0.3	0.3	0.2
	Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land converted to Grassland	kha	27.6	11.4	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.7

3) Carbon Stock Change in Soils in "Land converted to Grassland"

- ***Estimation Method***

Carbon stock changes in mineral soils in pasture land was estimated by applying the Tier 3 estimation method same as section 6.6.1.b)2). For the estimation, land which was once pasture land since 1970's was regarded as pastures land and used for calculation; the result of the calculation includes all grassland, regardless of land conversion. Therefore, carbon stock in mineral soil was reported regardless of whether or not land conversion has been occurred and carbon stock in pasture land converted from other land use was reported as "IE" since it was included in carbon stock in pasture land remaining pasture land. CO_2 emissions organic soils were estimated in pastures land remaining pasture land in a lump as was reported as "IE". For detailed information on the emission factors and activity data, see section 6.6.1.b)2).

[7] Cropland in the Japanese statistics includes pasture land which falls into grassland.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

Uncertainties of the parameters and the activity data for living biomass, dead organic matter, and soil were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty was estimated as 18% for the entire removal from the land converted to grassland.

- ***Time-series Consistency***

Although the methods to estimate the area of forest land converted to other land use are different between FY1990-2004 and post FY2005, as described in section 6.6.1.b)1), time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of grassland converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass and dead organic matter in this category were recalculated (FY2008-2013). For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Method of Obtaining Data of the "Areas converted from Other Land-use Categories to Grassland"***

The method used to obtain data on the area converted to grassland needs to be improved. For example, currently, the area of lands converted from forest land to grassland is estimated by multiplying the summed areas of forest land converted to cropland and grassland by the ratio of grazing land to the summed area. However, this estimation method may not represent the actual status of these areas. Therefore, the validity of the estimation method needs to be reviewed, and, if necessary, a new method of obtaining the area data should be considered.

- ***Method of Obtaining Data of the "Area converted from Cropland to Grassland"***

With respect to the method of obtaining data of the area converted from cropland to grassland, the converted area cannot be obtained from statistics except for the land-use conversion from cropland (rice field) to grassland (pasture land). For this reason, the estimates of the carbon stock changes in this land-use category may not fully reflect the actual conditions. Therefore, the methods used to obtain the following area data need to be investigated.

- from upland field to pasture land
- from orchard to pasture land
- from rice field to grazed meadow
- from upland field to grazed meadow
- from orchard to grazed meadow.

- ***Carbon Stock Changes in Mineral Soils in "Land converted to Grassland"***

Further improvement in method for estimating of the carbon stock changes in mineral soils is planned in the future.

- ***Estimation Method of Soil Carbon Stock Change upon "Land-Use Conversion from Other Land to Cropland"***

The estimation method will be considered when new data and information are obtained.

6.8. Wetlands (4.D)

Wetlands are lands that are covered with or soaked in water throughout the year. They do not fall under the categories of forest land, cropland, grassland, or settlements. The *2006 IPCC Guidelines* divides wetlands into three large groups: peat land, flooded land, and other wetlands. However, emissions and removals from other wetlands are not reported in Japan.

In FY2014, Japan's wetland area was about 1.34 million ha, which is equivalent to about 3.5% of the national land. The emissions from this category in FY2014 were 41 kt-CO_2. This represents a decrease of 51.6% below the FY1990 value and a decrease of 0.6% below the FY2013 value.

This section divides wetlands into two subcategories, "Wetlands remaining Wetlands (4.D.1.)" and "Land converted to Wetlands (4.D.2.)", and describes them separately in the following subsections.

Table 6-34 Emissions and removals in wetlands resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.D. Wetlands	Total	kt-CO_2	85	336	399	53	54	31	42	69	66	45	38	41	41
		Living Biomass	kt-CO_2	59	234	278	37	38	22	31	50	41	30	27	28	28
		Dead Wood	kt-CO_2	17	69	82	11	11	6	7	13	17	10	7	9	9
		Litter	kt-CO_2	8	33	39	5	5	3	4	6	8	5	4	4	4
		Mineral soil	kt-CO_2	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
		Organic soil	kt-CO_2	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
	4.D.1. Wetlands remaining Wetlands	Total	kt-CO_2	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
		Living Biomass	kt-CO_2	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
		Dead Wood	kt-CO_2	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
		Litter	kt-CO_2	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA	NO,NE,NA
		Mineral soil	kt-CO_2	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
		Organic soil	kt-CO_2	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
	4.D.2. Land converted to Wetlands	Total	kt-CO_2	85	336	399	53	54	31	42	69	66	45	38	41	41
		Living Biomass	kt-CO_2	59	234	278	37	38	22	31	50	41	30	27	28	28
		Dead Wood	kt-CO_2	17	69	82	11	11	6	7	13	17	10	7	9	9
		Litter	kt-CO_2	8	33	39	5	5	3	4	6	8	5	4	4	4
		Mineral soil	kt-CO_2	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
		Organic soil	kt-CO_2	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO	NA,NE,NO

6.8.1. Wetlands remaining Wetlands (4.D.1)

a) Category Description

This subcategory deals with carbon stock changes in wetlands which have remained as wetlands during the past 20 years.

For the change of mineral soil of carbon stocks managed for peat extraction, as a result of the domestic survey, it is found out that although peat extraction is carried out in Japan, estimating emissions with high accuracy is difficult. Therefore, based on the amount of emissions expected, carbon stock changes in organic soils that are managed for peat extraction are reported as "NE" that would be insignificant in terms of the likely level of emissions, described in the revision of the UNFCCC Guidelines. "Flooded land remaining flooded land" is not calculated at the present time as this is treated in an appendix in the *2006 IPCC Guidelines* and reported as "NE". "Other wetlands

remaining other wetlands" are reported as "NA" because the activity is not defined at the present time in Japan.

Table 6-35 Areas of wetlands remaining wetlands within the past 20 years

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Wetlands remaining Wetlands		kha	1,290.3	1,293.8	1,321.2	1,316.5	1,327.2	1,307.6	1,308.5	1,308.7	1,308.6	1,318.8	1,319.8	1,320.3	1,320.7
	Organic soils managed for peat extraction	kha	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Flooded land	kha	1,290.3	1,293.8	1,321.2	1,316.5	1,327.2	1,307.6	1,308.5	1,308.7	1,308.6	1,318.8	1,319.8	1,320.3	1,320.7
	other wetlands	kha	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) Category-specific Recalculations

Areas of wetlands remaining wetlands were estimated by subtracting areas of land converted to wetlands from the total wetlands areas. Areas of wetlands converted from forest land were revised due to revision of areas of deforestation (D area), which was used as original data for determining each land use area converted from forest land, in FY2008, FY2010 and FY2012. As a result, areas of wetlands remaining wetlands were also recalculated (FY2008-2013). For the impact of the recalculation, refer to Chapter 10.

6.8.2. Land converted to Wetlands (4.D.2)

a) Category Description

This subcategory deals with the carbon stock changes which occurred in the land that was converted from other land-use categories to wetlands, particularly to flooded land (i.e., dams) within the past 20 years. The emissions from this subcategory in FY2014 were 41 kt-CO_2; this represents a decrease of 51.6% below the FY1990 value and a decrease of 0.6% below the FY2013value.

With respect to living biomass, its carbon stock change as a result of land-use conversion from other land use to wetlands is estimated. This process includes both temporary loss of living biomass in the land before and subsequent gain after conversion.

With respect to dead organic matter, Japan used the CENTURY-jfos model to estimate carbon stocks in dead organic matter in forest land, and then estimated the carbon stock change in wetlands converted from forest land. Carbon stock changes in other subcategories were reported as "NA", supposing that no carbon stock change occur, or "NE" where suitable knowledge for estimating carbon stocks for the land-use categories were not available.

Carbon stock changes in soils in forest land converted to wetlands were reported as "NA". This was because the areas came to be reservoirs (dams), and their soils were supposed to become anaerobic condition; hence CO_2 emissions resulting from organic matter decomposition seemed to be extremely little. Since methodology is not provided by the *2006 IPCC Guidelines* and due to lack of data, carbon stock changes in soils in wetlands (flooded land) converted from land use other than forest land were not estimated. Therefore, the carbon stock changes in the carbon pool were reported as "NE".

b) Methodological Issues

1） Carbon stock change in Living biomass in "Landconverted to Wetlands"

- ***Estimation Method***

The Tier 2 method was applied for the land converted to wetlands (flooded land). The equations are given in section 6.6.2.b)1).

- ***Parameters***

➢ ***Biomass stock in each Land-Use Category***

The values shown in Table 6-8a and Table 6-8b are used for the estimation of biomass stock changes resulting from land-use conversion and subsequent changes in biomass stock due to biomass growth in converted land.

➢ ***Carbon Fraction of Dry Matter***

Average value of broad leaf trees and conifer trees (0.50t-C/t-d.m.) was applied as the carbon fraction of dry matter of forest. The default value (0.5 t-C/t-d.m.) was applied for other than forest.

- ***Activity Data (Area)***

Areas of land converted to wetlands (dam) were estimated based on the area of dam converted from forest land and the ratio of forest land among the area of land-use categories before conversion. The area of forest land converted to wetlands was calculated by the method described in section 6.6.2.b)1). With respect to areas of each land-use type before conversion to dam, percentages of each land area on dams converted from agricultural land (cropland and grassland) and settlements were estimated based on the numbers of dwellings and agricultural land areas which were submerged into certain large-scale dams. Breakdown of wetland areas converted from agricultural land into those converted from cropland and grassland were estimated by applying the current area percentages of land-use categories in the same manner of other land-use categories. The area remaining after deducting the areas of wetlands converted from forest land, cropland, grassland, and settlements from the total dam conversion area was regarded as other land converted to wetlands.

It should be noted that the area presented in the CRF "Table 4.D Sectoral background data for land use, land-use change and forestry－Wetlands" is not the annually converted area in FY2014 but the sum of annually converted areas during the past 20 years.

Table 6-36 Area of land annually converted to wetlands (single year)

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Wetlands	kha	0.43	1.72	2.04	0.27	0.28	0.16	0.18	0.33	0.43	0.25	0.19	0.22	0.22
Forest land converted to Wetlands	kha	0.31	1.24	1.48	0.20	0.20	0.12	0.13	0.24	0.31	0.18	0.14	0.16	0.16
Cropland converted to Wetlands	kha	0.025	0.096	0.107	0.015	0.014	0.008	0.010	0.017	0.023	0.013	0.010	0.011	0.012
Rice field	kha	0.007	0.023	0.006	0.003	0.001	0.001	0.001	0.002	0.002	0.001	0.001	0.001	0.002
Upland field	kha	0.013	0.054	0.077	0.009	0.010	0.006	0.007	0.012	0.016	0.010	0.007	0.009	0.008
Orchard	kha	0.005	0.018	0.023	0.003	0.003	0.002	0.002	0.003	0.004	0.003	0.002	0.002	0.002
Wetlands converted to Wetlands	kha	0.007	0.029	0.042	0.005	0.006	0.003	0.004	0.006	0.009	0.005	0.004	0.004	0.004
Settlements converted to Wetlands	kha	0.002	0.006	0.007	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
Other land converted to Wetlands	kha	0.09	0.34	0.41	0.05	0.06	0.03	0.04	0.07	0.09	0.05	0.04	0.04	0.04

2） Carbon Stock Change in Dead Organic Matter in "Land converted to Wetlands"

- ***Estimation Method***

➢ ***Carbon stock changes in Dead Organic Matter***

Carbon stock changes in dead organic matter in forest land converted to wetlands were estimated by applying the Tier 2 estimation method as described in section 6.6.2.b)2).

- ***Parameters***

➢ ***Carbon Stocks in Dead Organic Matter***

The average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 6-9 and 6-10. It is assumed that they become zero immediately after conversion, and are not

accumulated after conversion.

- ***Activity Data (Area)***

The area of land that was converted to wetlands during the past 20 years is determined by subtracting the estimated area that was not converted during the past 20 years from the total area of wetlands in those years. The areas are shown in Table 6-37 below.

Table 6-37 Area of land converted to wetlands within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Wetlands	kha	28.5	24.7	27.0	21.5	20.8	20.3	19.4	19.3	19.3	19.1	18.1	17.6	17.3
Forest land converted to Wetlands	kha	20.6	17.9	19.6	15.6	15.0	14.7	14.0	13.9	13.9	13.8	13.1	12.8	12.5
Cropland converted to Wetlands	kha	1.8	1.5	1.5	1.2	1.1	1.1	1.1	1.0	1.0	1.0	1.0	0.9	0.9
Rice field	kha	0.7	0.5	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Upland field	kha	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.6	0.6
Orchard	kha	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Grassland converted to Wetlands	kha	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Settlements converted to Wetlands	kha	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Other land converted to Wetlands	kha	5.7	4.9	5.4	4.3	4.2	4.1	3.9	3.9	3.9	3.8	3.6	3.5	3.5

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

Uncertainties of the parameters and the activity data for living biomass, dead organic matter, and soil were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty was estimated as 21% of the total emissions from the land converted to wetlands.

- ***Time-series Consistency***

Although the methods to estimate the area of forest land converted to other land use are different between FY1990-2004 and post FY2005, as described in section 6.6.2.b)1), time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of wetlands converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Validity of the Assumption used in the Method of Estimating the Area of Wetlands***

Under the present estimation method, wetlands are assumed to consist of “water surfaces”, “rivers” and “canals”, as defined in the national land-use classification, and the whole area is estimated by summing the areas covered by these three land types. However, this estimation method may fail to cover the entire wetland area. The validity of the assumption used in the estimation method is now

under revision.

- ***Method of Obtaining Data of the Area of Storage Reservoirs***

Storage reservoirs (excluding dams) can be considered as artificial flooded land, but the area they cover are not included in the area of flooded land. Therefore, a method used to obtain data on the area covered by the reservoirs needs to be considered.

- ***Estimation Method of Soil Carbon Stock Change upon "Land-Use Conversion from Other Land to Wetlands"***

The estimation method will be considered when new data and information are obtained.

6.9. Settlements (4.E)

Settlements are all developed land, including transportation infrastructure and human habitats, and preclude lands that have been placed in other land-use categories. In settlements, trees existing in urban green areas such as urban parks and special greenery conservation zones absorb carbon.

In FY2014, Japan's settlement area was about 3.81 million ha, equivalent to about 10.1% of the national land. The carbon stock changes in this category was 3,853 kt-CO_2 emissions in FY1990, 1,023 kt-CO_2 removals in FY2013, and 354 kt-CO_2 removals in FY2014.

In this section, settlements are divided into two subcategories, "Settlements remaining Settlements (4.E.1.)" and "Land converted to Settlements (4.E.2.)", and described separately in the following subsections.

Carbon pools estimated in settlements are living biomass, dead organic matter and soils. Dead organic matters for several subcategories are included in living biomass stock changes.

Urban green areas included in the activity data are divided into two categories; urban green facilities established as urban parks and others, and special greenery conservation zones for which conservation measures are taken and permanent protection is ensured.

- ***Urban green areas***

・ Urban Green Facilities (urban parks, green areas on roads, green areas at ports, green areas around sewage treatment facilities, green areas by greenery promoting system for private green space, green areas along rivers and erosion control sites, green areas around government buildings and green areas around public rental housing, which are within 30 years after establishment).
・ Special Greenery Conservation Zones, which are within 30 years after designation.

Table 6-38 Emissions and removals in settlements resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.E. Settlements	Total	kt-CO_2	3,853	2,009	-74	-629	-471	-1,352	-736	-524	202	-1,059	-708	-1,023	-354
		Living Biomass	kt-CO_2	2,480	1,173	-299	-707	-593	-1,204	-709	-592	-328	-1,021	-722	-954	-452
		Dead Wood	kt-CO_2	1,119	794	413	331	361	177	257	318	626	237	269	208	316
		Litter	kt-CO_2	524	365	181	140	155	66	105	135	285	97	113	84	138
		Mineral soil	kt-CO_2	-270	-323	-368	-394	-394	-391	-389	-386	-381	-372	-368	-361	-355
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	4.E.1. Settlements remaining Settlements	Total	kt-CO_2	-1,379	-1,647	-1,855	-2,013	-2,014	-2,010	-2,015	-2,028	-2,017	-1,974	-1,943	-1,896	-1,773
		Living Biomass	kt-CO_2	-1,147	-1,360	-1,522	-1,650	-1,649	-1,646	-1,651	-1,664	-1,655	-1,618	-1,588	-1,547	-1,428
		Dead Wood	kt-CO_2	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE
		Litter	kt-CO_2	-11	-13	-15	-17	-17	-17	-17	-17	-16	-16	-16	-16	-16
		Mineral soil	kt-CO_2	-222	-274	-318	-347	-348	-348	-348	-347	-345	-340	-338	-334	-330
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	4.E.2. Land converted to Settlements	Total	kt-CO_2	5,232	3,657	1,781	1,384	1,543	659	1,279	1,504	2,219	915	1,235	873	1,419
		Living Biomass	kt-CO_2	3,627	2,533	1,222	943	1,056	442	941	1,072	1,327	597	866	593	976
		Dead Wood	kt-CO_2	1,119	794	413	331	361	177	257	318	626	237	269	208	316
		Litter	kt-CO_2	535	379	196	157	171	83	122	152	302	114	130	100	153
		Mineral soil	kt-CO_2	-49	-49	-50	-47	-45	-43	-41	-38	-36	-33	-30	-27	-25
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

6.9.1. Settlements remaining Settlements (4.E.1)

a) Category Description

This subcategory deals with carbon stock changes in living biomass, litter of dead organic matter and soils in urban green areas in settlements remaining settlements, which have remained settlements without conversion during the past 20 years. This subcategory is divided into three subparts: “Special Greenery Conservation Zones”, “Urban Green Facilities” and “Other”. In these subparts, carbon stock changes in the “Special Greenery Conservation Zones” and “Urban Green Facilities” are estimated. In addition, carbon stock changes reported in “Revegetation (RV)” activities under Article 3, paragraph 4, of the Kyoto Protocol correspond to those in the “Urban Green Facilities” constructed in and after 1990[8]. However, “Special Greenery Conservation Zones” are not included in the areas of the Revegetation activities. In the CRF tables, “Special Greenery Conservation Zones” are described as “Urban Green Areas not subject to RV”, “Urban Green Facilities” as “Urban Green Areas subject to RV”, and “Other” as “Other than Urban Green Areas”, respectively. Carbon stock changes that are possibly included in the subpart “Other”, such as trees in gardens in personal residences, are reported as “NE” because their activity data are not available. Moreover, with respect to litter and soils, carbon stock changes in urban parks and green areas at ports are reported due to limited availability of parameters. The net removal by this subcategory in FY2014 was 1,773 kt-CO_2; this represents an increase of 28.6% over the FY1990 value and a decrease of 6.5% below the FY2013 value.

b) Methodological Issues

1） Carbon Stock Changes in Living Biomass in “Settlements remaining Settlements”

- ***Estimation Method***

Due to the differences of characteristics of urban green areas, the Tier 2a method is used for special greenery conservation zones that are communal green areas, and Tier 2b is used for urban green facilities.

The results of field survey on green area in settlements in Japan revealed that the trees have been

[8] The “Special Greenery Conservation Zones” are not included in Revegetation because they do not meet its definition.

growing for more than default growth period of 20 years, which are set on the Tier 2a and Tier 2b of the *2006 IPCC Guidelines*. It was concluded that, for up to 30 year tree, estimating gain of carbon stocks using the same factor as the 0~20 year trees absorption would be possible. Therefore, carbon stock changes in urban green areas younger than 30 years after establishment are estimated in the same way as 0~20 year urban green area.

➢ ***Tier 2a: Special Greenery Conservation Zones***

$$\Delta C_{SSaLB} = \Delta C_{LBaG} - \Delta C_{LBaL}$$

$$\Delta C_{LBaG} = A \times PW \times BI$$

ΔC_{SSaLB} : changes in carbon stocks in living biomass in special greenery conservation zones [t-C/yr]

ΔC_{LBaG} : gains in carbon stocks due to growth in living biomass in special greenery conservation zones [t-C/yr]

ΔC_{LBaL} : losses in carbon stocks due to losses in living biomass in special greenery conservation zones [t-C/yr]. Note: assumed as "0" (zero) in accordance with the *2006 IPCC Guidelines*

A : area of special greenery conservation zones younger than or equal to 20 years since designation [ha]

PW : rate of forested area (rate of forested area per park area). Note: assumed as 100%

BI : growth per crown cover area [t-C/ha crown cover/yr]

➢ ***Tier 2b: Urban Green Facilities***

$$\Delta C_{SSbLB} = \sum_i (\Delta C_{LBbGi} - \Delta C_{LBbLi})$$

$$\Delta C_{LBbGi} = \Delta B_{LBbGi}$$

$$\Delta B_{LBbGi} = \sum_j NT_{i,j} \times C_{Ratei,j}$$

ΔC_{SSbLB} : changes in carbon stocks in living biomass in urban green facilities [t-C/yr]

ΔC_{LBbG} : gains in carbon stocks due to growth in living biomass in urban green facilities [t-C/yr]

ΔC_{LBbL} : losses in carbon stocks due to losses in living biomass in urban green facilities [t-C/yr]. Note: assumed as "0" (zero) in accordance with the *2006 IPCC Guidelines*

ΔB_{LBbG} : Annual biomass growth in urban green facilities [t-C/yr)

C_{Rate} : Annual living biomass growth per tree [t-C/tree/yr)

NT : Number of trees

i : Types of urban green facilities (urban parks, green areas on roads, green areas at ports, green areas around sewage treatment facilities, green areas by greenery promoting systems for private green space, green areas along rivers and erosion control sites, green areas around government buildings, or green areas around public rental housing)

j : Tree species

● ***Parameters***

➢ ***Tier 2a: Annual rate of living biomass growth per crown cover area (special greenery conservation areas)***

The default value, 2.9 t-C/ha crown cover/yr, indicated in the *2006 IPCC Guidelines* (p. 8.9) is taken for the annual rate of living biomass growth of trees per crown cover area in special greenery conservation zones.

➢ ***Tier 2b: Annual rate of living biomass growth per tree (urban green facilities)***

The following parameters are taken as the annual living biomass growth rates per tree in urban green

facilities.

Table 6-39 Annual biomass growth rate per tree in urban green facilities

Climate category		Annual living biomass growth per tree [t-C/tree/yr]	Remarks
Urban green facilities	Hokkaido	(Other than green areas on roads) 0.0098 (Green areas on roads) 0.0103	Default values 0.0033-0.0142 [t-C/tree/y]) provided in the *2006 IPCC Guidelines* (p. 8.10, Table 8.2) and the annual growth rates of living biomass for the trees in Japan (0.0204 for Japanese zelkova, 0.0103 for ginkgo, 0.0095, for bamboo-leaf oak and 0.0122 t-C/tree/yr for camphor tree) are combined with the distribution ratio of tree types in sampled urban parks[9]. For green areas on roads, the distribution ratio of tree species indicated by the surveys in green areas on roads[10] is taken into account.
	Areas other than Hokkaido	(Other than green areas on roads) 0.0105 (Green areas on roads) 0.0108	

- ***Activity Data***

The areas of settlements remaining settlements in a certain year reported in the CRF tables are estimated by subtracting the cumulative total area of land converted to settlements during the past 20 years in a year subject to estimation from the total area of settlements in the year subject to estimation. Moreover, in the CRF tables, the areas of settlements remaining settlements are reported in three subparts: "Special Greenery Conservation Zones", "Urban Green Facilities" and "Other". Within these subparts, carbon stock changes in trees less than or equal to 30-year growth in "Special Greenery Conservation Zones" and "Urban Green Facilities" are estimated.

Japan assumes trees less than or equal to 30-year growth as those growing in urban green areas less than or equal to 30 years since establishment or designation. With respect to Tier 2a, tree crown areas in the "Special Greenery Conservation Zones" are applied as activity data. Tier 2b applies the number of tall trees planted in the "Urban Green Facilities" as activity data.

Table 6-40 Areas of settlements remaining settlements within the past 20 years

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Settlements remaining Settlements		kha	2,349.6	2,650.2	2,855.5	3,038.9	3,064.5	3,115.9	3,160.3	3,197.3	3,241.2	3,279.3	3,327.4	3,377.4	3,398.2
	Urban green facilities	kha	88.9	105.6	119.2	129.3	129.4	129.1	129.3	129.8	129.0	126.1	124.1	121.1	113.8
	Special greenery conservation zones	kha	1.9	3.7	3.8	4.1	4.0	4.0	4.1	4.2	4.2	4.4	4.4	4.5	4.5
	Other	kha	2,258.8	2,540.9	2,732.5	2,905.5	2,931.1	2,982.8	3,027.0	3,063.3	3,108.1	3,148.8	3,198.8	3,251.8	3,279.8

- ***Tier 2a: Tree crown areas ("Special Greenery Conservation Zones")***

The tree crown areas of the special greenery conservation zones are calculated by multiplying the area of special greenery conservation zones determined by the Ministry of Land, Infrastructure, Transport and Tourism by the rate of tree crown area, which is assumed to be 100%.

Table 6-41 Areas of special greenery conservation zones younger than or equal to 30 years since notification

[9] The annual growth rates of living biomass for these trees are calculated by using the growth curve for each tree species, which were developed based on the results of surveys conducted by the National Institute for Land and Infrastructure Management (NILIM) of the MLIT (Matsue et al., 2009) and the average trunk diameter at breast height for each tree species (Parks and Green Spaces Division of the MLIT, 2005), which were determined from the results of surveys in urban parks.

[10] The distribution ratio of tree types is taken from the *Road Tree Planting Status Survey (The Street tree of Japan VI)*, which covered green areas on roads throughout Japan.

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total		kha	1.9	3.7	3.8	4.1	4.0	4.0	4.1	4.2	4.2	4.4	4.4	4.5	4.5
	Green space conservation zones	kha	0.6	0.9	1.4	1.9	1.8	1.8	1.8	2.0	1.9	1.9	2.0	2.0	2.0
	Suburban green space conservation zones	kha	1.2	2.7	2.4	2.2	2.2	2.2	2.2	2.3	2.3	2.5	2.5	2.5	2.5

➢ ***Tier 2b: Number of tall trees ("Urban Green Facilities")***

The number of tall trees in urban green facilities is calculated according to the same methods that are used for revegetation activities under Article 3, paragraph 4, of the Kyoto Protocol. Brief descriptions of the calculation methods for each urban green facilities are stated below. In addition, for a detailed description of these calculation methods see section 11.4.2.7.a. in Chapter 11 in this NIR.

- ***Urban parks, green areas at ports, green areas around sewage treatment facilities, green areas along rivers and erosion control sites, green areas around government buildings, and green areas around public rental housing***

The number of tall trees is calculated by (1) calculating the areas falling under this category by multiplying each area by the area ratio of land conversion for the whole country, and then (2) calculating the number of tall trees in the calculated areas by multiplying each of the areas by the number of tall trees per area. The number of tall trees per area for each urban green facility is shown in the table below.

Table 6-42 Number of tall trees per area

Item	Unit	Number of tall trees per area	
		Hokkaido	Areas other than Hokkaido
Urban parks	tree/ha	329.5	222.3
Green areas at ports	tree/ha	329.5	222.3
Green areas around sewage treatment facilities	tree/ha	129.8	429.2
Green areas along rivers and erosion control	tree/ha	1470.8	339.0
Green areas around government buildings	tree/ha	108.8	108.8
Green areas around public rental housings	tree/ha	219.9	219.9

- ***Green areas on roads***

Activity data (the number of tall trees) in these facilities are calculated by the following procedures.

1. The number of tall trees planted during 30 years after establishing green areas on roads is calculated by using data from the "*Road Tree Planting Status Survey*" which had been implemented in FY1987, FY1992, FY2007 and each corresponding fiscal year during the commitment period,
2. The number of tall trees calculated in Step 1 is multiplied by the ratio of the number of tall trees planted on the roads whose planted area is more than 500 m^2,
3. The number of tall trees calculated in Step 2 is multiplied by the area ratio of settlements remaining settlements.

The values of Step 3 become the number of tall trees constituting the activity data on green areas on roads.

- ***Green areas by greenery promoting systems for private green space***

Activity data (the number of tall trees) are available for each facility. Therefore, the total number of tall trees is used as activity data.

2） Carbon Stock Changes in litter in "Settlements remaining Settlements"

In this category carbon stock changes in litter in urban parks and green areas at ports are estimated. Carbon stock changes in dead wood result in "IE" because they are included in carbon stock changes in living biomass. Carbon stock changes in litter in the subcategories other than urban parks and green areas at ports are not estimated due to the difficulty of obtaining such activity data.

- ***Estimation Method***

In accordance with the decision tree provided in the *2006 IPCC Guidelines*, a country-specific method is applied for this estimation. The estimation method is described below.

$$\Delta C_{SSLit} = \sum_i (A_i \times L_{it,i})$$

ΔC_{SSLit} : Carbon stock changes in litter in settlements remaining settlements [t-C/yr]
A : Area of urban parks and green areas at ports in settlements remaining settlements [ha]
L_{it} : Carbon stock change per area in urban parks or green areas at ports [t-C/ha/yr]
i : Type of Urban Green Facilities (urban parks or green areas at ports)

- ***Parameters***

For litter, Japan estimates carbon stock changes only in branches and leaves dropped naturally from tall trees. Carbon stock changes in litter per urban park area is calculated by using annual accumulation of litter per tree (Hokkaido and other prefectures: 0.0006 t-C/tree/yr) based on the results of field surveys in urban parks, and the number of tall trees per area and the ratio of litter moved to off-site due to management including cleaning (54.4%). As a result, carbon stock changes in litter per urban park area have been calculated to 0.0882 t-C/ha/yr for Hokkaido and 0.0594 t-C/ha/yr for other prefectures. In addition, the carbon fraction in litter is assumed to be 0.4 t-C/t-d.m. which is a default value provided in the *2006 IPCC Guidelines* (p. 8.21).

- ***Activity Data***

Activity data on this category are the same as those on living biomass in urban parks and green areas at ports, as described in activity data of "Remaining land: Above-ground biomass, Below-ground biomass" (section 11.5.1.1.f. a) of Chapter 11.

3） Carbon Stock Changes in Soils in "Settlements remaining Settlements"

Urban parks, for which the carbon stock changes in soils per area were determined, and Green areas at ports, whose management practices are similar to those for urban parks, are the subject of estimation. In general, soils in RV land are not organic soils (peat soils and muck soils). Therefore, organic soils are reported as "NO", and only mineral soils are estimated.

- ***Estimation Method***

Carbon stock changes in soils on settlements is estimated based on Tier 2 (Country specific data are used) estimation method.

$$\Delta C_{SSSoils} = \sum_i \left(\Delta C_{Mineral,i} - L_{Organic,i} \right)$$

$$\Delta C_{Mineral,i} = A_i \times \Delta C_{Soil,i}$$

$\Delta C_{SSSoils}$: Annual carbon stock changes in soils in settlements remaining settlements [t-C/yr]

$\Delta C_{Mineral}$: Annual carbon stock changes in mineral soils in settlements remaining settlements [t-C/yr]
$L_{Organic}$: Annual carbon stock changes in organic soils in settlements remaining settlements (=0) [t-C/yr]
A : Area of settlements remaining settlements [ha]
C_{Soil} : Annual carbon stock changes in soils per area of settlements remaining settlements [t-C/ha/yr]
i : Type of Urban Green Facilities (Urban parks and Green areas at ports)

- ***Parameters***

As described in section 11.5.1.1.f. d), carbon stock changes in soils per area of Urban parks and Green areas at port (integrated annual amount change 0-20 years after establishment is 1.28t-C/ha/yr, integrated annual amount change 21-30 years after establishment is 1.38t-C/ha/yr) are estimated based on the results of surveys conducted in urban parks which have been established within 30 years (Tonosaki et al., 2013, Parks, Green Spaces and Landscape Division, Ministry of Land, Infrastructure, Transport and Tourism, 2015). Thus, this value is applicable to Urban parks and Green areas at port which were established within 30 years.

- ***Activity Data***

Activity data on this category are the same as the area of urban parks and green areas at ports, as described in activity data of "Remaining land: Above-ground biomass, Below-ground biomass" (section 11.5.1.1.f. a) of Chapter 11).

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The default values shown on page 8.10 in the *2006 IPCC Guidelines* were applied to the annual carbon stock changes for trees in special greenery conservation zones. The uncertainty estimates for the emission and removal factors were determined by using the decision tree, to be ±50% through application of the standard value shown in the *2006 IPCC Guidelines* (page 8.12).

Moreover, the uncertainty estimates for living biomass in special greenery conservation zones apply expert judgment according to the decision tree for activity data.

Meanwhile, the uncertainty estimates for living biomass, dead organic matter and soil in urban parks, green areas on roads, green areas at ports, green areas around sewage treatment facilities, green areas by greenery promoting systems for private green space, green areas along rivers and erosion control sites, green areas around government buildings and green areas around public rental housing are 41%, 61%, 38%.

As a result, the uncertainty estimate was 34% for the entire removal by settlements remaining settlements.

- ***Time-series Consistency***

Although the methods to estimate the area of forest land converted to other land use" are different between FY1990-2004 and post 2005, as described in section 6.6.2.b)1), time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*.

The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of Settlements remaining Settlements were estimated by subtracting areas of land converted to Settlements from the total Settlements areas. Areas of Settlements converted from forest land were revised due to revision of areas of deforestation (D area), which was used as original data for determining each land use area converted from forest land, in FY2008, FY2010 and FY2012. As a result, areas of Settlements remaining Settlements and carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were also recalculated.

As for revegetation, carbon stock changes in soil had been calculated for 20 years after revegetation. However, a follow-up survey verified that carbon stock changes were generated during the period of 21-30 years after revegetation. Therefore, total amount of carbon soil changes was reviewed and carbon stock changes in mineral soil was recalculated (FY1990-2013). For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Growth Rate of Living Biomass per Unit of Greening Area in "Special Greenery Conservation Zones"***

The default values in the *2006 IPCC Guidelines* were applied to the living biomass growth rate per unit of greening area in special greenery conservation zones. However, the growth rate needs to be further examined, and a parameter that can be finally applied as the growth rate should be determined. Therefore, Japan is considering the characteristics of greening activity and will seek a parameter that best suits the actual situation.

- ***Validity of the Assumption used in the Method of Estimating the Area of Settlements***

The validity of the assumption is under re-examination.

6.9.2. Land converted to Settlements (4.E.2)

a) Category Description

This subcategory deals with the carbon stock changes in lands converted to settlements, which were converted from other land-use categories to settlements within the past 20 years. With respect to dead organic matter, Japan used the CENTURY-jfos model to estimate carbon stocks in dead organic matter in forest land, and then estimated carbon stock changes in forest land converted to settlements. However, the area of wetlands converted to settlements and other land converted to settlements cannot be obtained by the current method. Thus, carbon stock changes in these carbon pools were reported as "NO".

The net emissions by this subcategory in FY2014 were 1,419 kt-CO_2; this represents a decrease of 72.9% below the FY1990 value and an increase of 62.6% over the FY2013 value. Emissions from land converted to settlements increased from FY1990 to FY1993. After 1993, the emissions have been on a decreasing trend by 2003, and on a fluctuating trend from 2003 up to now. These trends resulted from annual changes of areas of land-use conversion from forest land to settlements.

b) Methodological Issues

1） Carbon stock changes in Living Biomass in "Land converted to Settlements"

- ***Estimation Method***

Carbon stock changes in living biomass in land converted to settlements are estimated by calculating the carbon stock changes before and after conversion and adding annual carbon stock changes in "Land converted to urban green facilities". The carbon stock changes in living biomass before and after conversion are estimated by applying the equation in section 2.3.1.2 in Volume 4 of the *2006 IPCC Guidelines* (multiplying the land area converted from each land use to settlements by the difference between the values of living biomass stock before and after conversion, and by the carbon fraction). Biomass stocks in land converted to urban green areas are increased due to the growth of trees planted after conversion. Hence, carbon stock changes in living biomass in land converted to urban green facilities are estimated by calculating carbon stock changes before and after conversion and adding annual carbon stock changes after conversion that are estimated by applying the Tier 2b method in section 8.2.1.1 in Volume 4 of in the *2006 IPCC Guidelines*.

$$\Delta C_{LSLB} = \sum_I \left\{ A_I \times (CR_a - CR_{b,I}) \times CF \right\} + \sum_i (\Delta C_{LS(UG)Gi} - \Delta C_{LS(UG)Li})$$

$$\Delta C_{LS(UG)G} = \Delta B_{LS(UG)G}$$

$$\Delta B_{LS(UG)G} = \sum_j NT_j \times C_{Ratej}$$

ΔC_{LSLB} : Carbon stock changes in living biomass in land converted to settlements [t-C/yr]

A_I : Area of land converted annually to settlements from land-use type *i* [ha/yr]

CR_a : Carbon reserves immediately following conversion to settlements [t-d.m./ha], default＝0

$CR_{b,I}$: Carbon reserves in land-use type *i* immediately before conversion to settlements [t-d.m./ha]

CF : Carbon fraction of dry matter [t-C/t-d.m.]

I : Type of land before conversion

$\Delta C_{LS(UG)Gi}$: Annual carbon stock gain in living biomass in land converted to urban green areas due to growth in living biomass [t-C/yr]

$\Delta C_{LS(UG)Li}$: Annual carbon stock loss in living biomass due to loss of living biomass [t-C/yr]
Note: the averaged ages of estimated trees are less than or equal to 30 years old; therefore, the loss is assumed as "0" (zero) based on the domestic survey and in accordance with the *2006 IPCC Guidelines*

$\Delta B_{LS(UG)G}$: Annual living biomass growth in land converted to urban green areas [t-C/yr]

C_{Rate} : Annual living biomass growth per tree [t-C/tree/yr]

NT : Number of trees

i : Type of urban green area after conversion (urban parks, green areas on roads, green areas at ports, green areas around sewage treatment facilities, green areas by greenery promoting systems for private green space, green areas along rivers and erosion control sites, green areas around government buildings, or green areas around public rental housing)

j : Tree species

- ***Parameters***

➢ ***Living biomass stocks for each land-use category***

Tables 6-8a and 6-8b show the living biomass stocks before and after conversion. Carbon stock losses due to loss of living biomass are assumed as "0" (zero) based on the domestic survey (*Parks, Green Spaces and Landscape Division, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)*, 2014) and in accordance with the *2006 IPCC Guidelines*, because trees subject to estimation are all

younger than or equal to 30 years old. Table 6-39 shows the annual living biomass growth of trees in land converted to urban green areas.

➢ ***Carbon fraction of dry matter***

Average value of broad leaf trees and conifer trees (0.50t-C/t-d.m.) was applied as the carbon fraction of dry matter of forest. The default value (0.5 t-C/t-d.m.) was applied for other than forest.

● ***Activity Data***

➢ ***Land Areas converted to Settlements***

With respect to the area of land converted to settlements, only the areas converted to settlements from forest land, cropland and grassland are determined. Since no data is available on the area converted to settlements from wetlands or other-land use categories, no figures are reported in those land-use categories. Instead, they are reported as "IE" since they are included in "Other land remaining Other land".

It should be noted that the area presented in the CRF "Table 4.E Sectoral background data for land use, land-use change and forestry－Settlements" is not the annually converted area in FY2014 but the sum of annually converted areas during the past 20 years.

- ***Conversion from Forest land***

Areas of forest land converted to settlements were estimated as described in section 6.6.2.b).1).

- ***Conversion from Cropland***

For former rice fields, upland fields, and orchards (according to "*Area Statistics for Cultivated and Commercially Planted Land*"), the areas of land converted to factories, roads, housing, and forest roads are used.

- ***Conversion from Grassland***

For former pasture land and grazed meadow land constituting moved or converted cropland which is converted to settlements (according to "*Area Statistics for Cultivated and Commercially Planted Land*" and "*A Move and Conversion of Cropland"*), the areas of land converted to factories, roads, housing, and forest roads are used.

Table 6-43 Area of land converted to settlements (single year)

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Settlements	kha	44.8	37.0	24.2	16.5	17.9	15.0	17.1	15.3	19.9	11.7	12.4	12.7	16.2
Forest land converted to Settlements	kha	20.2	14.3	7.5	6.0	6.5	3.2	4.6	5.8	11.4	4.3	4.9	3.8	5.8
Cropland converted to Settlements	kha	21.4	19.5	14.5	9.2	9.8	10.2	10.9	8.2	7.2	6.3	6.4	7.5	8.8
Rice field converted to Settlements	kha	13.0	12.1	9.5	6.0	6.4	6.5	7.1	5.0	4.1	3.5	3.9	4.3	5.0
Upland field converted to Settlements	kha	6.1	5.6	3.8	2.5	2.7	2.9	3.0	2.5	2.4	2.2	2.0	2.6	3.0
Orchard converted to Settlements	kha	2.3	1.8	1.1	0.7	0.7	0.8	0.8	0.7	0.6	0.6	0.5	0.7	0.8
Grassland converted to Settlements	kha	3.2	3.1	2.2	1.4	1.5	1.6	1.6	1.4	1.3	1.2	1.1	1.4	1.6
Wetlands converted to Settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

➢ ***Area and number of trees in "Land converted to urban green areas"***

The areas of land converted to urban green areas are calculated by multiplying the whole area of each urban green area by the area ratio of land conversion for the whole country. The number of trees is calculated by multiplying each urban green area converted from other land-use categories by the number of trees per area. For detailed information regarding these activity data see section 11.4.2.7.a.in Chapter 11 in this NIR.

2） Carbon Stock Change in Dead Organic Matter in "Land converted to Settlements"

In this category carbon stock changes in dead wood and litter in settlements converted from forest land, and those in litter in land converted to urban parks and green areas at ports are estimated.

With respect to dead wood, only the carbon stock change in forest land converted to settlements was estimated. The Tier 2 method was applied to the estimation in accordance with the method for conversion from other land use to cropland in the *2006 IPCC Guidelines*. Carbon stock changes in dead wood in land converted to urban green facilities are reported as "IE" because they are included in living biomass.

In regards to litter, the carbon stock changes in settlements converted from forest land and land converted to urban parks and green areas at ports are estimated. The Tier 2 method is applied to the estimation of the carbon stock changes in settlements converted from forest land in accordance with the method for conversion from other land use to cropland in the *2006 IPCC Guidelines*. Carbon stock changes in litter in land converted to urban parks and green areas at ports are estimated by applying Japan's country-specific estimation method due to the lack of an estimation method in the *2006 IPCC Guidelines*. Carbon stock changes in litter in land converted to urban green areas other than urban parks and green areas at ports are not estimated due to the difficulty of obtaining their activity data.

The area of wetlands converted to settlements and other land converted to settlements cannot be obtained by the current method. Thus, carbon stock changes in these carbon pools were reported as "NO".

- ***Estimation Method***

$$\Delta C_{LS} = \Delta C_{FS} + \Delta C_{LSLit}$$

ΔC_{FS} : Carbon stock changes in dead organic matter in settlements converted from forest land [t-C/yr]

ΔC_{LSLit} : Carbon stock changes in litter in urban parks and green areas at ports converted from land use categories other than forest land [t-C/yr]

➢ Carbon stock changes in dead organic matter in "Settlements converted from Forest land"

Carbon stock changes in dead organic matter in forest land converted to settlements are estimated by applying the Tier 1 estimation method described in section 2.3.2.2 in Volume 4 of the 2006 IPCC Guidelines. In addition, all carbon stocks in dead organic matter in the subcategory are assumed oxidized and emitted as CO_2 within the year of conversion.

$$\Delta C_{FS} = \sum_i \left\{ \left(C_{after,i} - C_{before,i} \right) \times A \right\}$$

ΔC_{FS} : Carbon stock changes in dead organic matter in forest land converted to settlements [t-C/yr]

$C_{after,i}$: Carbon stock in dead wood or litter after conversion [t-C/ha] Note: carbon stocks after conversion are assumed as "0" (zero).

$C_{before,i}$: Carbon stock in dead wood or litter before conversion [t-C/ha]

A : Area of forest land converted to settlements in a year subject to estimation [ha]

i : type of dead organic matter (dead wood or litter)

➢ ***Carbon stock changes in litter in "Urban parks and green areas at ports converted from land-use categories other than Forest land""***

$$\Delta C_{LSLit} = \sum_{I,i} \left\{ A_i \times (C_{AfterLit,i} - C_{BeforeLit,I}) + A_i \times Lit_i \right\}$$

ΔC_{LSLit} :Carbon stock changes in litter in urban parks and green areas at ports converted from land-use categories other than forest land [t-C/yr]

A : Area of urban parks or green areas at ports converted from land-use categories other than forest land for the past year [ha]

$C_{AfterLit,}$: Carbon stock in litter after conversion [t-C/ha]

$C_{BeforeLit}$: Carbon stock in litter before conversion [t-C/ha]

Lit : Annual carbon stock changes per area in litter in urban parks or green areas at ports converted from land-use categories other than forest land [t-C/ha/yr]

I : Land-use type before conversion

i : Type of urban green facility after conversion (urban parks or green areas at ports)

● ***Parameters***

➢ ***Carbon stocks in dead organic matter in "Forest land converted to Settlements"***

Average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 6-9 and 6-10. The average carbon stocks in these categories from FY1990 to FY2004 are not estimated; therefore the carbon stocks in FY2005 are substituted for them. In addition, it is assumed that they become zero immediately after conversion, and are not accumulated after conversion.

➢ ***Carbon stocks in litter in "Urban parks and green areas at ports converted from land-use categories other than Forest land"***

When urban parks and green areas at ports are converted from land-use categories other than forest land, litter stocked before conversion is not moved to off-site because the ground before conversion, including litter, is continuously used after conversion, or covered with additional soils brought externally. Hence, litter stocked before conversion does not decrease after conversion. In addition, litter stocks scarcely increase immediately after conversion because newly planted trees do not immediately produce litter. Due to these facts, carbon stock changes before and after conversion are regarded as "0" (zero). Litter stocks accumulated in a year after conversion are calculated by the same method as the one used for urban parks and green areas at ports in settlements remaining settlements due to the research finding that litter stocks are accumulated in the same way as those in settlements remaining settlements, namely by natural drop of fallen leaves and branches from trees in land converted to urban parks and green areas.

● ***Activity Data***

➢ ***Carbon stocks in dead organic matter in "Forest land converted to Settlements"***

The area of land that was converted from forest land to settlements during the past 20 years is determined by aggregating the areas converted from forest land to settlements during the past 20 years. For the areas, see Table 6-44 below.

Table 6-44 Area of land converted to settlements within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Settlements	kha	869.4	778.8	738.5	659.1	639.5	617.1	592.7	562.7	537.8	500.7	460.6	430.6	408.8
Forest land converted to Settlements	kha	289.5	312.6	306.3	269.9	258.7	243.2	226.3	208.7	199.9	180.8	159.9	145.0	136.0
Cropland converted to Settlements	kha	520.6	409.1	376.8	338.8	331.5	325.3	318.8	307.8	293.7	278.0	261.3	247.9	236.5
Rice field converted to Settlements	kha	320.9	252.1	236.6	215.2	211.3	207.8	204.6	197.6	188.7	178.9	168.3	159.3	151.8
Upland field converted to Settlements	kha	137.2	110.5	101.8	91.9	89.8	88.2	86.1	83.4	79.8	75.7	71.3	68.3	65.5
Orchard converted to Settlements	kha	62.4	46.5	38.5	31.6	30.4	29.3	28.1	26.8	25.2	23.4	21.7	20.4	19.2
Grassland converted to Settlements	kha	59.3	57.2	55.4	50.5	49.4	48.7	47.6	46.1	44.2	41.9	39.4	37.8	36.2
Wetlands converted to Settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

➢ ***Carbon stock changes in litter in "Land converted to urban parks and green areas at ports"***

Areas of land converted to urban green areas are calculated in the same manner as the carbon stock changes in living biomass in land converted to urban green areas. They are calculated by multiplying the areas of urban parks and green areas at ports by the area ratio of land conversion for the whole country, respectively. For detailed information regarding these areas see section 11.5.1.1.f f) in Chapter 11 in this NIR.

3） Carbon Stock Change in Soils in "Land converted to Settlements"

In this category, forestland converted to settlements, urban parks and green areas at ports, the management practices of which were similar to those in urban parks, were subject of estimation.

● ***Estimation Method***

Carbon stock changes in soils in land converted to settlements are estimated based on Tier 2 (Country specific methodology and data are used) estimation method.

$$\Delta C_{LSSoils\_all} = \Delta C_{FSSoils} + \Delta C_{LSSoils}$$

$\Delta C_{LSSoils\_all}$: Carbon stock changes in soils in land converted to settlements [t-C/yr]

$\Delta C_{FSSoils}$: Carbon stock changes in soils in forest land converted to settlements [t-C/yr]

$\Delta C_{LSSoils}$: Carbon stock changes in urban parks and green areas at ports in settlements converted from land use other than forest land [t-C/yr]

$$\Delta C_{LSSoils} = \sum_i \left(\Delta C_{LSMineral,i} - L_{LSOrganic,i} \right)$$

$$\Delta C_{LSMineral,i} = \Delta A_i \times \left(C_{AfterSoil} - C_{BeforeSoil} \right) + A_i \times \Delta C_{soil,i}$$

$\Delta C_{LSMineral}$: Annual carbon stock changes in mineral soils in urban parks and green areas at port following land-use conversion other than from forest land [t-C/yr]

$L_{LSOrganic}$: Annual carbon stock changes in organic soils in urban parks and green areas at port in settlements converted from land use other than from forest land (=0) [t-C/yr]

ΔA : Area of urban parks and green areas at port converted from land use other than forest land within a year [ha/yr]

$C_{AfterSoil}$: Soil carbon stocks immediately after land-use conversion [t-C/ha]

$C_{BeforeSoil}$: Soil carbon stocks before land-use conversion [t-C/ha]

A : Area of urban parks and green areas at port converted from land use other than forest land [ha]

ΔC_{Soil} : Annual carbon stock changes in soils per land area of urban parks and green areas at port following land-use conversion other than from forest land [t-C/ha/yr]

i : Type of urban green facilities (urban parks or green areas at ports)

- ***Parameters***

Parameters described in Table 6-11 were applied to estimation of carbon stock changes in soils in forest land converted to settlements. In addition, when urban parks were constructed, soils in the areas before conversion were almost never moved to off-site. In general, these soils were continuously used in the same places after conversion or covered by additional soils. Therefore, carbon stock changes in soils resulting from land conversion did not occur.

The parameters same as for urban parks and green areas at port in settlements remaining settlements were used for estimation of carbon stock changes in soils in urban green facilities converted from land use other than forest land.

- ***Activity Data***

➢ ***Forest land converted to settlements***

The values shown in Table 6-44 were applied to forest land converted to settlements.

➢ ***Settlements converted from land use other than forest land***

The activity data of settlements converted from land use other than forest land were the same as urban parks and green areas at port described in section 11.5.1.1.f. f) in Chapter 11.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of the parameters and activity data for living biomass and dead organic matter were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty estimate was 21% for the entire emission from land converted to settlements.

- ***Time-series consistency***

Although the methods to estimate the area of forest land converted to other land use are different between FY1990-2004 and post FY2005, as described in section 6.6.2.b)1), time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of Settlements converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Validity of the Assumption used in the Method of Estimating the Area of Settlements***

The areas of forest land converted to settlements are presently assumed as “roads”, “human habitats”, “school reservations”, “parks and green areas”, “road sites”, “environmental facility sites”, “golf courses”, “ski courses” and “other recreation sites” in the national land-use categorization; however, this assumption may fail to cover all the areas. Therefore, the validity of the assumption needs to be re-examined.

6.10. Other land (4.F)

Other land consists of land areas that are not included in the other five land-use categories. As concrete examples of other land, the *2006 IPCC Guidelines* indicates bare land, rock, ice, and all land areas that do not fall into any of the five categories. In FY2014, Japan’s other land area was about 2.28 million ha, which is equivalent to about 6.0% of the national land. The classification of other land is shown in Table 6-45 below[11].

Table 6-45 Land included in the other land category

Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Other land		kha	2,164	2,267	2,213	2,206	2,208	2,247	2,255	2,276	2,275	2,314	2,316	2,316	2,317
	Defense Facility Site	kha	139	140	140	140	140	140	140	140	140	140	140	140	140
	Cultivation Abandonment Area	kha	46	46	46	46	46	46	46	46	46	46	46	46	46
	Coast	kha	504	504	504	504	504	504	504	504	504	504	504	504	504
	Northern Territories	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other	kha	1,476	1,577	1,524	1,517	1,519	1,558	1,565	1,586	1,585	1,624	1,626	1,626	1,627

The emissions from this category in FY2014 were 166 kt-CO_2; this represents a decrease of 88.6% below the FY1990 value and an increase of 71.0% over the FY2013 value.

This section divides other land into two subcategories, “Other land remaining Other land (4.F.1.)” and “Land converted to Other land (4.F.2.)”, and describes them separately in the following subsections.

[11] These land areas are based on the following statistics: “*Defense of Japan*” by the Ministry of Defense for “Defense Facility Site”, “*Digital national land information*” by MLIT for “Coast” and “*Land Survey of Prefectures, Shi, Ku, Machi and Mura*” by the Geographical Survey Institute for “Northern Territories”.

Table 6-46 Emissions and removals resulting from carbon stock changes in other land

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	4.F. Other land	Total	kt-CO_2	1,455	1,220	902	153	201	110	177	139	241	121	161	97	166
		Living Biomass	kt-CO_2	948	785	564	55	91	30	84	59	115	55	83	39	90
		Dead Wood	kt-CO_2	277	228	165	15	26	8	19	14	48	11	21	11	25
		Litter	kt-CO_2	133	109	79	7	12	4	9	7	23	5	10	5	12
		Mineral soil	kt-CO_2	96	98	93	76	72	68	64	58	54	50	46	42	38
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	4.F.1. Other land remaining Other land	Total	kt-CO_2													
		Living Biomass	kt-CO_2													
		Dead Wood	kt-CO_2													
		Litter	kt-CO_2													
		Mineral soil	kt-CO_2													
		Organic soil	kt-CO_2													
	4.F.2. Land converted to Other land	Total	kt-CO_2	1,455	1,220	902	153	201	110	177	139	241	121	161	97	166
		Living Biomass	kt-CO_2	948	785	564	55	91	30	84	59	115	55	83	39	90
		Dead Wood	kt-CO_2	277	228	165	15	26	8	19	14	48	11	21	11	25
		Litter	kt-CO_2	133	109	79	7	12	4	9	7	23	5	10	5	12
		Mineral soil	kt-CO_2	96	98	93	76	72	68	64	58	54	50	46	42	38
		Organic soil	kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

6.10.1. Other land remaining Other land (4.F.1)

a) Category Description

This subcategory deals with carbon stock changes in other land remaining other land during the past 20 years. The land area of this subcategory is determined by subtracting the summed areas of the other five land-use categories from the total national land area shown in the *Statistical Reports on the Land Area by Prefectures and Municipalities in Japan* compiled by the Geospatial Information Authority of Japan. In concrete terms, the land area of this category includes defense facility sites, coasts, and northern territories. However, carbon stock changes in this subcategory are not considered in accordance with the *2006 IPCC Guidelines*.

Table 6-47 Areas of other land remaining other land within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Other land remaining Other land	kha	2,276.4	2,336.9	2,285.6	2,181.9	2,196.2	2,216.8	2,236.9	2,275.3	2,258.2	2,303.2	2,318.9	2,127.2	2,191.3

b) Category-specific Recalculations

There have been no source-specific recalculations

c) Category-specific Planned Improvements

None.

6.10.2. Land converted to Other land (4.F.2)

a) Category Description

This subcategory deals with carbon stock changes in the land converted to other land within the past 20 years. The land area of this subcategory includes land converted for soil and stone mining, land damaged by natural disasters, and land in which cultivation is abandoned. The emissions from this subcategory in FY2014 were 165.8 kt-CO_2. This represents a decrease of 88.6% below the FY1990

value and a decrease of 71.0% below the FY2013 value.

With respect to living biomass, its carbon stock change as a result of land use conversion from other land use to other land was estimated.

With respect to dead organic matter, Japan used the CENTURY-jfos model to estimate carbon stocks in dead organic matter in forest land, and then estimated carbon stock changes in forest land converted to other land. Carbon stock changes in dead organic matter in other subcategories (conversion from cropland and grassland) were reported as "NA", since dead organic matter pools before and after conversion were assumed to be zero, as described in section 6.6.2.b)2) and 6.7.2.b)2).

With respect to carbon stock changes in soils, carbon stock changes in soils in forest land converted to other land are estimated. Carbon stock changes in soils in land other than forest land converted to other land are not estimated due to lack of data.

In addition, the area of wetlands converted to other land and settlements converted to other land cannot be obtained by the current method. Thus, carbon stock changes in these carbon pools were reported as "NO".

b) Methodological Issues

1） Carbon stock change in Living Biomass in "Land converted to Other land"

- ***Estimation Method***

The Tier 2 method was applied as described in section 6.6.2.b)1). Carbon stock changes due to biomass growth in other land were assumed as zero.

- ***Parameters***

➢ ***Biomass stock in each Land-Use Category***

The values shown in Tables 6-8a and 6-8b are used for the estimation of biomass stock changes upon land-use conversion and subsequent changes in biomass stock due to biomass growth in converted land.

➢ ***Carbon Fraction of dry matter***

Average value of broad leaf trees and conifer trees (0.50t-C/t-d.m.) was applied as the carbon fraction of dry matter of forest. The default value (0.5 t-C/t-d.m.) was applied for other than forest.

- ***Activity Data (Area)***

Only the areas converted from forest land and cropland to other land are determined. Since no data were available on the area converted from wetlands and settlements to other land, estimations for those land-use categories could not be made. Instead, they are reported as "IE" since they are included in "Other land remaining Other land".

It should be noted that the area presented in the CRF "Table 4.F Sectoral background data for land use, land-use change and forestry－Other land" is not the annually converted area in FY2014 but the sum of annually converted areas during the past 20 years.

➢ ***Conversion from Forest Land***

See section 6.6.2.b)1).

➢ ***Conversion from Cropland***

For former rice fields, upland fields, and orchards, the area classified as "other, natural disaster damage" is used according to *the Area Statistics for Cultivated and Commercially Planted Land*.

➢ ***Conversion from Grassland***

For former pasture land and grazed meadow land, the area of former pasture land classified as "other, natural disaster damage" (according to *the Area Statistics for Cultivated and Commercially Planted Land*) and the area of former grazed meadow land which is classified as "other, classification unknown" (*the Move and Conversion of Cropland*) are used.

Table 6-48 Area of land converted to other land (single year)

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Other land	kha	7.5	7.3	5.1	4.9	1.4	1.1	1.4	1.7	1.9	17.9	3.0	1.2	2.7
Forest land converted to Other land	kha	5.0	4.1	3.0	0.3	0.5	0.1	0.3	0.3	0.9	0.2	0.4	0.2	0.5
Cropland converted to Other land	kha	2.2	2.6	2.0	4.5	0.8	0.8	0.9	1.2	0.9	16.8	2.3	0.8	2.0
Rice field	kha	1.2	1.5	1.6	4.2	0.5	0.5	0.5	0.8	0.6	14.9	1.7	0.3	1.3
Upland field	kha	0.7	0.9	0.3	0.2	0.2	0.3	0.3	0.4	0.2	1.6	0.5	0.4	0.5
Orchard	kha	0.3	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.1	0.1	0.1
Grassland converted to Other land	kha	0.4	0.5	0.2	0.2	0.1	0.1	0.1	0.2	0.1	0.8	0.3	0.2	0.3
Wetlands converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Settlements converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

2） Carbon Stock Changes in Dead Organic Matter in "Land converted to Other land"

● ***Estimation Method***

Carbon stock changes in dead organic matter in forest land converted to other land were estimated by applying the Tier 2 estimation method as described in section 6.6.2.b)2).

● ***Parameters***

➢ ***Carbon Stocks in Dead Organic Matter in "Other Land converted from Forest Land"***

The average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 6-9 and 6-10. It is assumed that carbon stocks become zero immediately after conversion, and are not accumulated after conversion.

● ***Activity Data (Area)***

The values of annually converted area from each land-use category to other land during the past 20 years are summed up to obtain the total area that is converted to other land during the same time period.

Table 6-49 Area of land converted to other land within the past 20 years

Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Land converted to Other land	kha	174.7	158.1	143.7	127.1	121.8	116.4	111.0	104.6	99.0	109.4	106.2	98.4	92.7
Forest land converted to Other land	kha	103.8	105.1	99.7	81.9	76.9	72.1	67.6	62.0	57.9	52.4	48.4	43.1	38.6
Cropland converted to Other land	kha	55.8	41.1	36.9	38.3	38.0	37.5	36.9	36.3	35.1	50.5	51.5	49.7	48.8
Rice field	kha	32.4	20.9	20.3	22.8	22.9	22.9	22.8	23.2	22.6	36.9	38.1	37.1	36.8
Upland field	kha	16.1	14.2	12.0	11.5	11.2	11.0	10.6	10.0	9.5	10.4	10.3	9.7	9.4
Orchard	kha	7.3	5.9	4.5	4.0	3.8	3.7	3.5	3.2	3.0	3.2	3.1	2.9	2.7
Grassland converted to Other land	kha	15.1	12.0	7.1	7.0	6.9	6.7	6.5	6.2	6.0	6.5	6.3	5.7	5.2
Wetlands converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
Settlements converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE

3） Carbon Stock Changes in Soils in "Land converted to Other land"

In this category, carbon stock changes in mineral soils in forest land converted to other land were estimated.

- ***Estimation Method***

Carbon stock changes in mineral soils in this category were estimated as same as section 6.6.2.b)3.

- ***Parameters***

The parameters described in Table 6-11 were applied to estimating the carbon stock changes in mineral soils in forest land converted to other land.

- ***Activity Data (Area)***

The areas of forest land converted to other land within 20 years were calculated by summing the annually converted areas during the past 20 years. The areas were shown in Table 6-49.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of the parameters and the activity data for living biomass and dead organic matter were individually assessed on the basis of field study results, expert judgment, or the default values described in the *2006 IPCC Guidelines*. The uncertainty was estimated as 17% for the entire emission from the land converted to other land.

- ***Time-series Consistency***

Although the methods to estimate the area of forest land converted to other land use are different between FY1990-2004 and post FY2005, as described in section 6.6.2.b)1), the time-series consistency for this subcategory is basically ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Areas of Other land converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

- ***Breakdown Analysis of Other Land and Reclassification into Other Land-Use Categories***

A further breakdown analysis of the other land is required, since it may still include some areas that are supposed to be classified into other land-use categories even after the reallocation carried out in this year.

- ***Carbon Stock Changes in Living Biomass in "Land converted to Other Land"***

The carbon stock changes in living biomass in land converted to other land were assumed to be zero because of a lack of reference information for other land. However, this assumption may differ from the actual situation. Therefore, the methods used to quantifying the carbon stock are being examined.

- ***Estimation Method of Soil Carbon Stock Changes in "Forest land, Cropland and Grassland converted to Other Land"***

The estimation method will be considered when new data and information are obtained.

6.11. Harvested Wood Products (4. G)

Harvested Wood Products (HWP) that have been removed from forest through harvest, carbon sequestration as organic substances and store these substances while HWP has been used, such as in housing materials and furniture. Eventually, CO_2 emissions are emitted when it is discarded due to incineration or decay.

This category deals with annual carbon stock changes in the HWP pool. The HWP (such as sawn-wood, wooden board, plywood and, paper and paperboard) that are produced from "ikusei-rin forest" which forest management practices are implemented in forest land, is subject to estimation. The changes in carbon stock associated with use or disposal are estimated. The net emissions (carbon stock changes) from this subcategory in FY 1990 were 856.7 kt-CO_2, in FY2013 were 374.5 kt-CO_2. The net removal in FY2014 were 621.4 kt-CO_2. The primary reasons for the removal fluctuation since FY1990 in the category were due to economic situation and effect of disaster.

In this section, the HWP is divided into three subcategories: "buildings", "wood used for other than buildings" and "paper and paperboard", these subcategories are described separately in the following subsections.

Table 6-50 CO_2 emissions and removals associated with carbon stock change in HWP pool

Gas	Category		Unit	1990	1995	2000	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	Total		kt-CO_2	856.7	2,790.7	2,078.6	1,678.4	1,629.7	1,306.8	190.7	150.9	1,282.4	878.6	3,277.9	484.1	374.5	-621.4
	Buildings	Total	kt-CO_2	849.4	559.2	349.1	-22.8	240.3	172.5	-857.1	-1,104.6	-891.6	-685.2	1,722.7	-1,099.5	-812.6	-1,402.5
		Sawnwood	kt-CO_2	978.6	765.9	627.5	293.7	580.8	557.9	-290.4	-373.7	-321.4	-30.9	2,240.9	-499.6	-143.5	-703.3
		Wooden board	kt-CO_2	-189.6	-271.1	-360.8	-324.3	-287.6	-313.6	-411.0	-421.3	-253.0	-289.3	-238.9	-221.7	-220.1	-282.6
		Plywood	kt-CO_2	60.4	64.4	82.3	7.8	-52.9	-71.8	-155.7	-309.6	-317.2	-365.0	-279.2	-378.3	-448.9	-416.7
	Wood used for other than building	Total	kt-CO_2	543.4	1,067.6	1,320.1	1,277.9	1,203.4	1,050.4	967.1	995.0	1,113.9	937.5	916.7	904.8	762.6	694.7
		Sawnwood	kt-CO_2	954.5	1,294.6	1,478.0	1,451.3	1,484.9	1,361.6	1,355.8	1,352.3	1,480.8	1,421.4	1,227.4	1,313.2	1,235.1	1,170.6
		Wooden board	kt-CO_2	-405.5	-291.8	-259.8	-171.5	-172.3	-153.4	-112.5	-51.5	21.3	-9.8	-12.4	-107.9	-113.1	-124.4
		Plywood	kt-CO_2	-5.6	64.8	101.9	-1.9	-109.3	-157.9	-276.2	-305.9	-388.2	-474.1	-298.4	-300.5	-359.4	-351.5
	Paper and paperboard		kt-CO_2	-536.0	1,163.9	409.4	423.2	186.1	84.0	80.6	260.6	1,060.2	626.3	638.5	678.7	424.5	86.4

6.11.1. Buildings

a) Category Description

This category deals with annual change in carbon stock in sawnwood, wooden board, and plywood used in buildings. The net emissions (carbon stock changes) from this subcategory in FY 1990 were 849.4 kt-CO_2. The net removal in FY2013 were 812.6 kt-CO_2, in FY2014 were 1402.5 kt-CO_2.

b) Methodological Issues

- ***Estimation Method***

Since sawn-wood, wooden board, and plywood for the use of buildings account for a major proportion of wood use, and statistics related to the buildings have been compiled with a certain accuracy in Japan, the carbon stock changes in these pool are estimated by using country-specific stock inventory method (Tier 3) which obtains directly carbon stock changes that is included in the buildings.

Sawn-wood, wooden board and plywood used in the buildings are reported in “Sawnwood”, “Wood panels”, and “Other solid wood products” under ”Solid wood” in the CRF tables, respectively.

The carbon stock changes in sawn-wood, wooden board, and plywood used in the buildings were estimated by using carbon stocks (inflow) in sawn-wood, wooden board and plywood that are used when buildings are constructed, and discarded carbon (outflow) when the buildings are destroyed. The estimation equation is as follows:

$$\Delta C_j(i) = Inflow_j(i) - Outflow_j(i)$$

i : Year
j : Subcategory (sawnwood, wooden board, plywood)
$Inflow_j(i)$: Inflow to the HWP pools during year i [t-C/year]
$Outflow_j(i)$: Outflow from the HWP pools during year i [C/year]
$\Delta C_j(i)$: Changes in carbon stock in HWP products during year i [t-C/year]

Regarding the carbon stock (inflow) in sawnwood, wooden board, and plywood that are used when buildings are constructed, and discarded carbon (outflow) when the buildings are destroyed, were calculated by the following equations.

$$Inflow_j(i) = \left\{S_{p(st)}(i) * v_j(st) * f_{jDP}(i) - V_{IM}(i)\right\} * D_j * CF_j$$
$$Outflow_J(i) = S_{W(st)}(i) * v_j(st) * f_{jDW}(i) * D_j * CF_j$$
$$S_{W(st)}(i+1) = S_{S(st)}(i) - S_{S(st)}(i+1) + S_{P(st)}(i)$$

i : Year
j : Subcategory (sawnwood, wooden board, plywood)
$Inflow_j(i)$: Annual carbon inflow to the HWP pools during year i [t-C/year]
$Outflow_j(i)$: Outflow from the HWP pools during year i [t-C/year]
$S_{p(st)}(i)$: Floor area of construction by use (residential or nonresidential) and by structure [m^2/year]
$v_j(st)$: Wood input per unit area [m^3/m^2]
$S_{W(st)}(i)$: Floor area of destroyed by use (residential or nonresidential) and by structure [m^2/year]
$f_{jDP}(i)$: Rate of domestic logs to total logs used for construction in each year [%]
$f_{jDW}(i)$: Rate of domestic logs for destroyed building in each year [%]
$V_{IM}(i)$: Amount of wood used for imported houses in each year [m^3]
D_j : Density [t-d.m./m^3]
CF_j : Carbon fraction [t-C/t-d.m.]
$S_{S(st)}(i)$: Floor area stock by use (residential or nonresidential building) and by structure in each year [m^2/year]

- ***Parameters***

➢ ***Wood input per unit area (m^3/m^2)***

- ***Sawnwood***

As for wooden residential building, amount of wood used per unit area of 1991 to 2011 were identified by exiting statistics (*Survey on Actual Demand of Construction Labor and Materials* by the MLIT).

As for non-wood residential building, the values of 2013 are obtained from the survey which was implemented newly because there was available only data until 1991 in the *Survey on Actual Demand of Construction Labor and Materials* by the MLIT above. The values of 1992 to 2012 were calculated by interpolation by means of linear expression.

- ***Wooden board***

The amount of wood used for each type of wooden board by utilization were calculated by multiplying the rate of shipment quantity of wooden board for each type to total shipment quantity, by the shipment quantity of wooden board for each type in *Yearbook of Current Production Statistics, Paper, Ceramics and building materials Statistics* by METI. The wood used per unit area were estimated by dividing the amount of wood used which is calculated above, by the floor areas of building construction.

- ***Plywood***

The values obtained from the *Survey on Actual Demand of Construction Labor and Materials* by the MLIT were applied. As for the years that data are missing, the values were calculated by interpolation by means of linear expression.

➢ ***Rate of domestic logs***

- ***Sawnwood***

The rate of domestic logs for sawnwood by conifer and non-conifer was calculated by dividing shipment quantity of domestic sawnwood for buildings, by the total amount of shipment quantity of sawnwood for buildings and imported sawnwood.

- ***Wooden board***

Shipment quantity of wooden board (domestic logs) used for buildings as raw material were calculated by multiplying proportion of raw materials of particle board and fiberboard, by the rate of domestic logs for each raw material (logs, wood residue in mills and forestry practices and scrap wood). The rate of domestic logs for each wooden board type were estimated by dividing the shipment quantity of wooden board (domestic logs) above, by the total amount of shipment quantity of wooden board used in buildings and imports of wooden board used in buildings.

- ***Plywood***

The rates of domestic logs for plywood used in building constructed was calculated by multiplying rate of production of plywood to the total amount of plywood production and imports of plywood, by production of plywood from domestic logs.

➢ ***Density and Carbon fraction***

The default values (Table 2.8.1) described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* were applied.

Table 6-51 Default values of density and carbon fraction for the HWP categories

HWP categories		Density [Mg/m^3]	Carbon fraction [Mg-C/Mg-d. m.]
Sawnwood	Coniferous sawnwood	0.45	0.5
	Non-coniferous sawnwood	0.56	0.5
Wood panels (wooden board)	Particle board (PB)	0.596	0.451
	Hardboard (HDF)	0.788	0.425
	Medium-density fireboard (MDF)	0.691	0.427
	Insulating board (other board, low density fiber)	0.159	0.474
Wood panels (plywood)		0.542	0.493

(the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*: Table 2.8.1)

Table 6-52 Data used for estimation (Buildings)

	Variable	Source	Note
1	Shipment quantity of sawlogs (for building) (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
2	Shipment quantity of sawlogs (for building) (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	
3	Received quantity of logs for sawlogs	*Report on Supply and Demand of Lumber (the Survey on Lumber)* by MAFF	
4	Imports of lumber (coniferous tree)	*Trade Statistics of Japan* by MOF	Softwood (coniferous tree) is assumed as building materials because imports for building structures cannot be obtained in the statistics.
5	Production of plywood	*Report on Supply and Demand of Lumber* by MAFF	
6	Imports of veneer for plywood	*Trade Statistics of Japan* by MOF	Calculated by multiplying rate of veneer for plywood to imports of veneer, by imports of veneer obtained from FAOSTAT
7	Imports of plywood	*FAOSTAT* by FAO *Trade Statistics of Japan* by MOF	Calculated by subtracting bonded wood and bamboo of plywood by *Trade Statistics of Japan* from bonded wood by *FAOSTAT*
8	Received quantity of logs for plywood (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
9	Received quantity of logs for plywood (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	
10	Shipment quantity of wooden board	*Yearbook of Current Production Statistics, Paper, Ceramics and building materials Statistics* by METI	Including own-use
11	Imports of wooden board	*Trade Statistics of Japan* by MOF	
12	Imported wood chips	*Trade Statistics of Japan* by MOF	
13	Production of domestic wood chips	*Report on Supply and Demand of Lumber* by MAFF	
14	Quantity of arrival logs for wood chips (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
15	Quantity of arrival of logs for wood chips (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	
16	Shipment quantity of wooden board by use	*Shipments of wood-based board production* by Japan Fiberboard and Particleboard Manufacturers Association	

MIC: Ministry of Internal Affairs and Communications; METI: Ministry of Economy, Trade and Industry; MOF: Ministry of Finance

- ***Activity Data***

Floor area of construction by use (residential or nonresidential) and by structure were used in *Construction Statistics for Housing* and *Construction Statistics for Building* by MLIT, and floor area stock were used in *Fixed Property Tax Division, Local Tax Bureau (Houses)* by MIC. And furthermore, floor area of destroyed were calculated by these statistics.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of carbon stock changes of buildings were assessed based on the uncertainties of the default factors provided in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* and the uncertainties of exiting statistical data. The uncertainty was estimated as 30% for the carbon stock changes in buildings.

- ***Time-series Consistency***

Since wood input per unit area were obtained from the *Survey on Actual Demand of Construction Labor and Materials* by the MLIT which is implemented every three years, the data for missing years were calculated by interpolation by means of linear expression. The time-series consistency for this subcategory is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculation was carried out based on reviewing the activity data to reflect the actual condition. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

Due to increased use of wood to interior material caused by the revision of Building Code Act and dissemination of Cross Laminated Timber (CLT), there is a possibility that the wood input per unit area will be changed in the future.

6.11.2. Wood used for other than buildings

a) Category Description

This category deals with carbon stock changes in sawnwood, wooden board, and plywood used in other than buildings. The net emissions (carbon stock changes) from this subcategory in FY 1990 were 543.4 kt-CO_2, in FY2013 were 762.6 kt-CO_2, in FY2014 were 694.7 kt-CO_2.

b) Methodological Issues

- ***Estimation Method***

The carbon stock change of the HWP pool of this category were estimated by using the Tier 2 method used the first-order decay (FOD) function described in the 2*013 Revised Supplementary Methods and*

Good Practice Guidance Arising from the Kyoto Protocol. Inflow to the HWP pool during one year were estimated by multiplying amount of wood used in other than buildings, rate of domestic logs of each subcategory (sawnwood, wooden board and plywood), by carbon conversion factor. The estimation equations are as follows.

In the CRF tables, "Sawnwood" are reported as "Sawnwood for non-buildings", "Wooden board" as "Wooden board for non-buildings", and "Plywood" as "Plywood for non-buildings" under "Other (please specify)", respectively.

$$C_j(i+1) = e^{-k_j} \cdot C_j(i) + \left[\frac{\left(1-e^{-k_j}\right)}{k_j}\right] \cdot Inflow_j(i)$$

$$\Delta C_j(i) = C_j(i+1) - C_j(i)$$

i : Year
j : Subcategories (sawnwood, wooden board and plywood)
$C_j(i)$: Carbon stock of the HWP pool in the beginning of year i [t-C]
$Inflow_j(i)$: Inflow to the HWP pool during year i [t-C/year]
k : Decay constant of FOD for each HWP category, k＝ln(2)/HL
HL: half-life of the HWP pool in years
$\Delta C_j(i)$: Carbon stock change in the HWP category during year *i* [t-C/year]
$C_j(1900)$: Carbon stock in 1900 was assumed to be zero

$$Inflow_j(i) = V_{jP}(i) \cdot f_{DP}(i) \cdot D_j \cdot CF$$

i : Year
j : Subcategories (sawnwood, wooden board and plywood)
$V_{jP}(i)$: Amount of wood used in other than buildings [m^3/year]
$f_{DP}(i)$: Rate of domestic logs used in other than buildings during year i [%]
D_j : Density [t-d.m./m^3]
CF : Carbon fraction [t-C/t]

- ***Parameters***

➢ ***Rate of domestic logs***

- ***Sawnwood***

The rates of domestic logs for sawnwood used for other than buildings were calculated by dividing the shipment quantity of sawnwood used for domestic logs by species of tree, by the shipment quantity.

- ***Wooden board***

The rates of domestic logs for wooden board production were estimated by multiplying proportion of raw materials used for practical board and fiber board, by the rate of domestic logs for each raw material (logs, wood residue in mills and forestry practices, and scrap wood).

- ***Plywood***

The rates of domestic logs used for other than buildings, were calculated by dividing the plywood arrivals of domestic logs used for other than buildings by total received volume of plywood and imports of veneer for plywood which have converted to roundwood.

➢ ***Default Half-lives***

The default half-lives (sawnwood: 35 year, wood panels: 25 year) described in *the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* were applied (Table 2.8.2). The default half-lives of wood panels are used for wooden board and plywood.

➢ ***Density and Carbon fraction***

The default values used are the same as section 6.11.1 "Building" (See Table 6-51 for the details).

Table 6-53 Data used for estimation (wood used for other than buildings)

	Variable	Source	Note
1	Shipment quantity of wooden board	*Yearbook of Current Production Statistics, Paper, Ceramics and building materials Statistics* by METI	Including own-use
2	Shipment quantity of lumber (for other than domestic logs and building lumber)	*Report on Supply and Demand of Lumber* by MAFF	
3	Imports of plywood (veneer)	*Trade Statistics of Japan* by MOF	Calculated by multiplying rate of veneer for plywood to imports of veneer, by imports of veneer obtained from FAOSTAT
4	Received quantity of logs for plywood (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
5	Received quantity of logs for plywood (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	
6	Imported wood chips	*Trade Statistics of Japan* by MOF	
7	Production of domestic wood chips	*Report on Supply and Demand of Lumber* by MAFF	
8	Domestic wood chips (for pulp)	*Trends in Pulp Collection* by Japan Paper Association	
9	Received quantity of logs for wood chips (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
10	Received quantity of logs for wood chips (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	

METI: Ministry of Economy, Trade and Industry; MOF: Ministry of Finance

● ***Activity Data***

Production of lumber and Production of plywood were used in *Report on Supply and Demand of Lumber (the Survey on Lumber)* by MAFF. Production of lumber were reduced shipment quantity of lumber from domestic logs and building material

● ***Method of tracing back up to 1900***

As for wood used for other than buildings, they were extrapolated backward to 1990 using the equation 12.6 described in section 12.2.3 in *the 2006 IPCC Guidelines*. For the estimated annual rate for industrial round wood production (U), default value of Asia between 1900 and 1961 (0.0217) was used (*2006 IPCC Guidelines*, Table 12.3).

$$V_t = V_{1961} \cdot e^{[U \cdot (t-1961)]}$$

V_t : Annual production for other wood use [kt- C/year]

t : Year

V_{1961} : Annual production for other wood use for the year 1961 [kt- C/year]

U : Estimated continuous rate of change in industrial roundwood consumption for the region that includes the reporting country between 1900 and 1961

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of carbon stock changes of wood use other than buildings were assessed based on the uncertainties of the default factors in provided in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* and the uncertainties of statistical data. The uncertainty was estimated as 30% for the carbon stock changes in wood used for other than buildings.

- ***Time-series Consistency***

The data before 1961 were extrapolated backward to 1990 using the equation 12.6 described in section 12.2.3 in *the 2006 IPCC Guidelines*, the time-series consistency for this subcategory is ensured. The activity data and any parameter after 1962 were used consistent statistics.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculation was carried out based on reviewing the activity data to reflect the actual condition. For the impact of the recalculation, refer to Chapter 10

f) Category-specific Planned Improvements

Wood which is used mainly in roundwood form in civil engineering and construction field, are not estimated at present.

6.11.3. Paper and paperboard

a) Category Description

This category deals with carbon stock changes in paper and paperboard (including waste paper). The net removal (carbon stock changes) from this subcategory in FY 1990 were 536.0 kt-CO_2, the net emissions in FY2013 were 424.5 kt-CO_2, in FY2014 were 86.4 kt-CO_2.

b) Methodological Issues

- ***Estimation Method***

The carbon stocks change of the HWP pool in paper and paperboard were estimated in the same way as wood for other use by using the Tier 2 method used first order decay (FOD) function described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. Inflow to the HWP pool during one year were estimated by multiplying amount of production of paper and paperboard, rate of domestic logs for paper and paperboard, by carbon conversion factor. The estimation equations are as follows.

$$\mathrm{C}_j(i+1) = e^{-k_j} \cdot \mathrm{C}_j(i) + \left[\frac{\left(1-e^{-k_j}\right)}{k_j}\right] \cdot Inflow_j(i)$$

$$\Delta C(i) = C(i+1) - C(i)$$

i : year

$C(i)$: Carbon stock in HWP pool in the beginning of year i [t-C]

$Inflow\ (i)$: Inflow to the HWP pool during year i [t-C/year]

k_j : Decay constant of FOD for paper products, k_j = ln(2)/HL

HL: half-life of the HWP pool : two years

$\Delta C(i)$: Carbon stock change of the HWP category during year i [t-C/year]

$C_{(1900)}$: Carbon stock in 1900 was assumed to be zero

$$Inflow_j(i) = PP_{jp}(i) \cdot f_{DP(PP)}(i) \cdot D_j \cdot CF$$

$PP_{jP}(i)$: Production of paper and paperboard during year i [t]

$f_{DP(PP)}$(i) : Rate of domestic logs for paper and paperboard during year i [%]

D_j : Density (oven dry mass over air dry mass)

CF : Carbon conversion factor [t-C/t-d.m.]

- ***Parameters***

➢ ***Rate of domestic logs***

Rate of domestic logs of paper and paperboard was estimated by dividing domestic production of paper and paperboard, by total amount of domestic production of paper and paperboard, waste paper and waste paper pulp that were produced from domestic logs.

➢ ***Half-live***

Default half-life of paper and paperboard (2 year) described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (Tables 2.8.2) was used.

➢ ***Default conversion factors for Paper and paperboard***

Default parameters (oven dry mass over air dry mass: 0.9 t-d.m./t, carbon conversion factor: 0.386 t-C/t-d.m.) for paper and paperboard described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* (Tables 2.8.2) were used.

Table 6-54 Data used for estimation (Paper and paperboard)

	Variable	Source	Note
1	Rate of domestic production of pulp	*Yearbook of Current Production Statistics, Paper, Printing, Plastic Products and Rubber Products Statistics Current Survey of Production* by METI	
2	Production of waste paper	*Yearbook of Current Production Statistics, Paper, Printing, Plastic Products and Rubber Products Statistics Current Survey of Production* by METI	FAOSTAT (Recovered paper)
3	Imports and Exports of waste paper	*Trade Statistics of Japan* by MOF	FAOSTAT (Recovered paper)
4	Imports and Exports of paper and paperboard	*Trade Statistics of Japan* by MOF	FAOSTAT (Recovered paper)
5	Rate of production of wood chips	*Report on Supply and Demand of Lumber* by MAFF	
6	Received quantity of logs for wood chips (domestic logs)	*Report on Supply and Demand of Lumber* by MAFF	
7	Received quantity of logs for wood chips (imported logs)	*Report on Supply and Demand of Lumber* by MAFF	
8	Domestic wood chips for pulp products	*Yearbook of Current Production Statistics, Paper, Printing, Plastic Products and Rubber Products Statistics Current Survey of Production* by METI	
9	Imported wood chips for pulp products	*Yearbook of Current Production Statistics, Paper, Printing, Plastic Products and Rubber Products Statistics Current Survey of Production* by METI	

METI: Ministry of Economy, Trade and Industry; MOF: Ministry of Finance

- ***Activity Data***

Amount of production of paper, paperboard and domestic logs (Pulpwood and Chips) were used in *Yearbook of Current Production Statistics, Paper, Printing, Plastic Products and Rubber Products Statistics Current Survey of Production* by METI.

- ***Method of tracing back up to 1900***

For paper and paperboard, the estimation method is the same as wood used for other than buildings. For detailed information on the equation and the parameters, see section 6.11.2.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of carbon stock changes of paper and paperboard were assessed based on the uncertainties of the default factors provided in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* and the uncertainties of exiting statistical data.

The uncertainty was estimated as 30% for carbon stock changes in paper and paperboard.

- ***Time-series Consistency***

The data before 1961 were extrapolated backward to 1990 using the equation 12.6 described in section 12.2.3 in *the 2006 IPCC Guidelines*, the time-series consistency for this subcategory is ensured. The activity data and any parameter after 1962 were used consistent statistics.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Recalculation was carried out based on reviewing the activity data to reflect the actual condition. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

None.

6.12. Direct N_2O emissions from N inputs to managed soils (4. (I))

a) Category Description

This category deals with direct N_2O emissions from N fertilization in land other than cropland and grassland. The direct N_2O emissions from N fertilization in forest land were estimated but N_2O emissions from N fertilization in wetlands and settlements were reported as "IE" because those are included in the agriculture sector. The emissions by this subcategory in FY2014 were 0.56kt-CO_2 eq. This represents a decrease of 33.0% below the FY1990 value.

Table 6-55 Direct N_2O emissions from N fertilization

Gas	Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N_2O	Total		kt-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
			kt-CO_2 eq.	0.84	0.72	0.67	0.64	0.69	0.63	0.46	0.48	0.56	0.53	0.54	0.56	0.56
	Forest land	Inorganic N fertilizers	kt-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Forest land remaining Forest land	Inorganic N fertilizers	kt-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Land converted to Forest land	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Wetlands	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Wetlands remaining Wetlands	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Land converted to Wetlands	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Settlements	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Settlements land remaining Settlements	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Land converted to Settlements	Inorganic N fertilizers	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Other	Inorganic N fertilizers	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) Methodological Issues

- ***Estimation Method***

The direct N_2O emissions from N fertilization in forest land were estimated by applying Tier 2 estimation method based on decision tree described in the *2006 IPCC Guidelines* because country specific emission factors can be used. The estimation equation was the same as the agriculture sector.

- ***Parameters***

➢ ***Emission factor***

The emission factor (0.62% [kg-N_2O-N/kg-N[12]]), which was applied to the estimation of N_2O emissions resulting from application of synthetic fertilizer to agricultural soils, was also applied to the estimation of N_2O emissions from N fertilization to soils in forest land. For detailed information on the emission factor, see section 5.5.1.1.b) in chapter 5 in this NIR.

- ***Activity Data***

Results of surveys from 2006 to 2008 on fertilizer application to soils in forest land by the Forestry

[12] Akiyama et al., Direct N_2O emissions and estimate of N_2O emission factors from Japanese agricultural soils. (2006)

Agency of Japan are activity data. The amount of synthetic fertilizer applied to soils in forest land in the years in which the surveyed data did not exist was estimated by multiplying the total amount of synthetic fertilizer application in *Yearbook of Fertilizer Statistics (Pocket Edition)* by the average percentage of synthetic fertilizer application to soils in forest land in the period from 2006 to 2008.

With respect to kinds of fertilizer applied to soils in forest land, most of them are synthetic fertilizer according to the surveys by the Forestry Agency of Japan. Hence, the fertilizer applied to soils in forest land is regarded as synthetic fertilizer. The average percentage is 0.047% of the total amount of synthetic fertilizer application.

Since the application of crop residues to forest land and the grazing in the forest land have not been carried out, the amount of crop residues applied to soils in forest land and, grazing land, and paddock were zero.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainty estimates of N_2O emissions from N fertilization were 31% by applying the same value as the estimation of the N_2O emissions from N fertilization in the agriculture sector.

- ***Time-series Consistency***

The emission factor is constant throughout the time series. For activity data, the same sources are multiplied by same ratio throughout the time series. Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since *Yearbook of Fertilizer Statistics (Pocket Edition)* was updated, the emissions in FY2013 were revised. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

None.

6.13. Emissions and Removals from Drainage and Rewetting and Other Management of Organic and Mineral soils (4.(II))

a) Category Description

Regarding the non-CO_2 emissions from drainage and rewetting and other management of organic and mineral soils, the emissions from drainage of organic soils were estimated in Japan. CH_4 emission from drainage of organic soils in upland fields and pasture land were estimated in this subcategory. Regarding the rewetted organic soils and coastal wetlands rewetting that methodology is described in the *Wetlands guidelines*, the estimation method has not been applied. Hence, the emissions were reported as “NA”.

Regarding the emissions from soil drainage activities in forest land, the non-CO_2 emissions did not occur, because soil drainage activities were not carried out in general in Japan. CH_4 and N_2O emissions from drainage of organic soils in forest land are reported as "NO". As explained in section 4.D.1, peatland classified as wetlands was reported as "NE" because it can be considered insignificant in terms of overall level and trend in national emissions. Flooded land and other wetlands were reported as "NA" because the estimation method was not applied.

The emissions by this subcategory in FY2014 were 37.0 kt-CO_2 eq. This represents a decrease of 4.5% below the FY1990 value, and a decrease of 0.3 % below the FY2013 value.

Table 6-56 CH_4 emission from drainage of organic soils

Gas	Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All	Total	kt-CO_2 eq.	38.8	37.6	37.4	37.4	37.4	37.4	37.4	37.3	37.3	37.1	37.1	37.1	37.0
CH_4	Total	kt-CH_4	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
		kt-CO_2 eq.	38.8	37.6	37.4	37.4	37.4	37.4	37.4	37.3	37.3	37.1	37.1	37.1	37.0
	Forest land	kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Cropland	kt-CH_4	1.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	Grassland	kt-CH_4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Wetlands	kt-CH_4	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
	Peat land	kt-CH_4	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Flooded land	kt-CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Other wetlands	kt-CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Other	kt-CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	Total	kt-N_2O													
		kt-CO_2 eq.													
	Forest land	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Wetlands	kt-N_2O	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
	Peat land	kt-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Flooded land	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Other wetlands	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Other	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Organic Soil	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Mineral Soil	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from drained inland organic soils were estimated by using Tier 1 method described in section 2.2.2.1 in the *Wetlands guidelines*. The estimation equation is as follows:

$$CH_{4-organic} = \sum \{A \times [(1 - Frac_{ditch}) \times EF_{CH4\_land} + Frac_{ditch} \times EF_{CH4\_ditch}]\}$$

CH_4-*organic* : Annual CH_4 loss from drained organic soils [kg-CH_4]

A : Land area of drained organic soils [ha]

EF_{CH4_land} : Emission factors for direct CH_4 from drained organic soil [kg-CH_4/ha]

EF_{CH4_ditch} : Emission factors for CH_4 emissions from drainage ditches [kg-CH_4/ha]

$Frac_{ditch}$: Fraction of the total area of drained organic soil which is occupied by ditches

- ***Parameters***

The following emission factors for CH_4 from drained organic soil, emission factors for CH_4 from drainage ditches, and the proportion of ditches to the total area of drained organic soil which were provided by the *Wetlands guidelines* Table 2.3 and Table 2.4, were applied to the estimation.

Table 6-57 CH_4 emission factors for drained organic soils (land surface)

Land-use category	Emission factor	Unit	Climate/ vegetation zones
Cropland, drained	0	$kgCH_4/ha/yr$	Cropland, temperate
Grassland, deep-drained, nutrient-rich	16	$kgCH_4/ha/yr$	Grassland, deep-drained, nutrient rich, temperate

Wetlands guidelines: Table 2.3

Table 6-58 Default CH_4 emission factors for drained organic ditches

Land-use category	Emission factor	Unit	$Frac_{ditch}$ (indicative values)	Climate/ vegetation zones
Deep-drained Grassland, Cropland	1165	$kgCH_4/ha/yr$	0.05	Boreal/ Temperate

Wetlands guidelines: Table 2.4

- ***Activity Data***

For detailed information on the methods of determining the areas of organic soils in upland fields and grassland, see section 6.6.1 and section 6.7.1.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties for parameters were assessed on the basis of default values described in the *Wetlands guidelines.* As a result, the uncertainty estimates for the CH_4 emissions from drained inland organic soils were 115%.

- ***Time-series Consistency***

The emission factor is constant throughout the time series. For activity data, the same sources are used throughout the time series. Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since area of deforestation (D area) were revised, the emissions from FY2008 to FY2013 were revised. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

None.

6.14. Direct N_2O emissions from N mineralization/immobilization associated with loss/gain of soil organic matter resulting from change of land use or management of mineral soils (4.(III))

a) Category Description

This category deals with direct N_2O emissions from N mineralization resulting from change of land use or management of mineral soils. Therefore, according to the *2006 IPCC Guidelines*, N

immobilization associated with gain of soil carbon on mineral soils is not considered, only N_2O emissions from mineralization associated with loss of soil organic matter were estimated.

The direct N_2O emissions in forest land remaining forest land and land converted to other land were estimated by using Tier 1 method according to N mineralization associated with loss of soil organic matter. The N_2O emissions in land converted to cropland and grassland converted from land were estimated using the same country specific emission factors as for the agriculture sector. For land-use categories other than those categories described above, N_2O emissions were reported as "NA" because the loss of soil carbon does not occur. (Only for wetland converted from land was reported as "NE" because the methodology is not provided in the *2006 IPCC Guidelines*) The emissions by this subcategory in FY2014 were 143.3 kt-CO_2 eq. This represents a decrease of 24.2 % below the FY1990 value, and an increase of 0.3 % over the FY2013 value.

Table 6-59 N_2O emissions from N mineralization resulting from change of land use or management of mineral soils

Gas	Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
N_2O	Total	kt-N_2O	0.63	0.61	0.57	0.53	0.52	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48
		kt-CO_2 eq.	189.1	182.2	170.8	158.6	155.7	152.8	149.9	147.2	145.4	144.1	142.8	142.9	143.3
	Forest land	kt-N_2O	0.41	0.41	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	Forest land remaining Forest land	kt-N_2O	0.41	0.41	0.41	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
	Land converted to Forest land	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Cropland	kt-N_2O	0.17	0.14	0.11	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.03
	Land converted to Cropland	kt-N_2O	0.17	0.14	0.11	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.03
	Graassland	kt-N_2O	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Grassland remaining Grassland	kt-N_2O	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Land converted to Graassland	kt-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Wetlands	kt-N_2O	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA	NE,NA
	Wetlands remaining Wetlands	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Land converted to Wetlands	kt-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Settlements	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Settlements remaining Settlements	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Land converted to Settlements	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Other land	kt-N_2O	0.04	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01

b) Methodological Issues

- ***Estimation Method***

The Tier 1 method described in the *2006 IPCC Guidelines* is used for forest land remaining forest land and other land. The estimation equation is as follows. Equation 2.25 described Session 2.3.3.1 in the *2006 IPCC Guidelines* is used for loss of soil organic matter.

$$N_2O_{direct}\text{-}N_{mineral} = F_{SOM} \times EF_1$$

$$F_{SOM} = \sum_{LU}\left[\left(\Delta C_{Mineral,LU} \times \frac{1}{R}\right) \times 1000\right]$$

$N_2O_{direct}\text{-}N_{mineral}$: Annual direct N_2O-N emissions produced from N mineralization [kg-N_2O-N]

F_{SOM} : Net amount of N mineralized in mineral soil [kg-N]

EF_1 : Emission factor [kg-N_2O-N/kg-N input]

$\Delta C_{Mineral,LU}$: Average annual loss of soil carbon for each land-use type [t-C]

R : C:N ratio for the soil organic matter

For land converted to cropland and grassland, annual amount of loss of soil carbon of N mineralized in mineral soils cannot be obtained, when using the estimation method described in the *2006 IPCC*

Guidelines. Therefore, N_2O emissions from land converted to cropland and grassland were estimated by using country specific method, by multiplying the area of mineral soils in cropland remaining cropland and in grassland remaining grassland, by the N_2O emission per unit area in cropland. For a detailed description of the calculation methods, see the agriculture sector.

$$N_2O_{direct}\text{-}N_{mineral\_C,G} = \sum_i A_i \times EF_{1\_C,G}$$

$N_2O\ direct\text{-}N_{mineral\_C,G}$: Annual direct N_2O-N emissions produced from N mineralization [kg-N_2O-N]
A : The cumulative total mineral soil area of land converted to cropland and grassland [ha]
$EF_{1\_C,G}$: N_2O emission from N mineralization per unit area of mineral soil [kg-N_2O-N/ha]
i : Type of land use

- ***Parameters***

➢ ***CN ratio for soils***

11.3 (Country specific data (Ministry of the Environment, 2006))

➢ ***N-N_2O emission factor for soils***

For forest land and other land, default value [0.01 kg- N_2O-N/kg- N] described in the *2006 IPCC Guidelines* was used. For cropland and grassland, the value used in the agriculture sector [0.23 kg-N_2O-N/ha] was applied. (For detailed information, see section 5.5.1.5.b).

- ***Activity Data***

For amount of N mineralized in mineral soil in forest land remaining forest land and in other land, annual loss of soil carbon in mineral soil for estimating carbon stock changes in mineral soils was used (see Chapter 6.5.2. and Chapter 6.10.2.). The area of mineral soil in land converted to cropland, which are calculated by subtracting the area of organic soil from the total area of land converted to cropland, are used for the estimation as activity data (see Chapter 6.6.1.).

The area of mineral soil in grassland was calculated by multiplying the area of pasture land obtained from existing statistics by the ratio of mineral soil area to the area of pasture land by renewal ratio (3%) of pasture land (see Chapter 6.7.1.).

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainties of emission/removal for forest land and other land were assessed on the basis of carbon stock change in soil and C:N ratio for the soil organic matter. The uncertainties of parameters described in the *2006 IPCC Guidelines* were used. For the uncertainty assessment for cropland and grassland converted from other land-use category, 31% the same value of the uncertainties for the emissions in the agriculture sector was applied. As a result, the uncertainties in the N_2O emissions from N mineralization associated with loss of soil organic matter were -59%~+159%.

- ***Time-series Consistency***

The emission factor is constant throughout the time series. For activity data, the same sources are used throughout the time series. Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since N-N_2O emission factor for soils were revised, the emissions from FY1990 to FY2013 were recalculate. For the impact of the recalculation, refer to Chapter 10.

f) Not applicable. Category-specific Planned Improvements

None.

6.15. Indirect nitrous oxide (N_2O) emissions from managed soils (4.(IV))

a) Category Description

This category deals with indirect N_2O emissions from managed soils. The indirect N_2O emissions include, N_2O emissions from volatilization of N as NH_3 and NO_x and deposition of these gases and their products NH_4^+ and NO_3^- onto soils and the surface of lakes and other waters, and N_2O emissions from leaching and runoff in regions where leaching and runoff occurs. In Japan, the indirect N_2O emissions from N fertilization in forest land and the indirect N_2O emissions from N mineralization associated with loss of soil organic matter were estimated.

The emissions from this category in FY2014 were 31.7 kt-CO_2 eq. This represents a decrease of the 21.9% below FY1990 value, and an increase of 0.4% over FY2013 value.

Table 6-60 Indirect NO_2 emissions from managed soils

Gas	Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NO_2	Total		kt-N_2O	0.14	0.13	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
			kt-CO_2 eq.	40.6	38.7	36.3	34.3	33.8	33.3	32.7	32.3	32.0	31.7	31.5	31.6	31.7
		Atmospheric deposition	kt-N_2O	0.0005	0.0004	0.0004	0.0003	0.0004	0.0003	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
		Nitrogen leaching and run-off	kt-N_2O	0.14	0.13	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

b) Methodological Issues

1） N_2O emission from atmospheric deposition of N volatilized

- ***Estimation Method***

The Tier 1 method described in section 11.2.1.1 in the *2006 IPCC Guidelines* is used.

$$N_2O_{(ATD)} - N = \left[(F_{SN} \times Frac_{GASF}) + ((F_{ON} + F_{PRP}) \times Frac_{GASM})\right] \times EF_4$$

$N_2O_{(ATD)}$-N : Annual amount of N_2O–N produced from atmospheric deposition of N volatilized [kg N_2O-N]

F_{SN} : Annual amount of synthetic fertilizer N applied to forest land [kg-N]

F_{ON} : Annual amount of organic N additions applied to forest land [kg-N]

F_{PRP} : Annual amount of urine and dung N deposited by grazing animals on pasture, range and paddock [kg-N]

$Frac_{GASF}$: Fraction of synthetic fertilizer N that volatilized as NH_3 and NO_X [kg-NH_3-N + NO_X-N/kg-N applied]

$Frac_{GASM}$: Fraction of applied organic N fertilizer (FON) and of urine and dung N deposited by

grazing animals (FPRP) that volatilizes as NH3 and NOx [kg-NH_3-N + NO_X-N/kg-N]

EF_4 : Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces [kg-N_2O-N/kg-NH_3-N+NO_X-N]

- ***Parameters***

➢ ***Fraction of fertilizer N that volatilized as NH_3 and NO_X***

0.1 [kg NH_3-N +NOx-N/kg N applied] (Table 11.3 in Vol.4 of the *2006 IPCC Guidelines*)

➢ ***Emission factor (N volatilization and re-deposition)***

0.01 [kg N_2O-N/kg NH_3-N +NOx-N volatilized] (Table 11.3 in Vol.4 of the *2006 IPCC Guidelines*)

- ***Activity Data***

For amount of N fertilizer applied to forest land, see section 6.12 in this NIR.

2） N_2O emission from leaching/runoff

- ***Estimation Method***

The Tier 1 method described in section 11.2.2.1 in the *2006 IPCC Guidelines* is used.

$$N_2O_{(L)} - N = (F_{SN} + F_{ON} + F_{PRP} + F_{CR} + F_{SOM}) \times Frac_{LEACH-(H)} \times EF_5$$

$N_2O_{(L)}$-N : Annual amount of N_2O–N produced from leaching and runoff of N additions [kg N_2O-N]

F_{CR} : Amount of N in crop residues [kg-N]

F_{SOM} : Annual amount of N mineralized in mineral soils associated with loss of soil C from soil organic matter [kg-N]

$Frac_{LEACH-(H)}$: Fraction of all N mineralized in managed soils in regions where leaching/runoff occurs that is lost through leaching and runoff [kg-N/kg-N]

EF_5 : Emission factor for N_2O emissions from N leaching and runoff [kg-N_2O-N]

- ***Parameters***

➢ ***Fraction of all N mineralized in managed soils***

0.3 [kg N/kg nitrogen of fertilizer] (Table 11.3 in Vol.4 of the *2006 IPCC Guidelines*)

➢ ***Emission factor (N leaching and runoff)***

0.0075 [kg N_2O-N/(kg N leaching/runoff)] (Table 11.3 in Vol.4 of the *2006 IPCC Guidelines*)

- ***Activity Data***

For amount of N fertilizer applied to forest land, see section 6.12 in this NIR. For amount of N mineralization associated with loss of soil organic matter, see section 6.13 in this NIR.

c) Uncertainties and Time-series Consistency

- ***Uncertainty Assessment***

The uncertainty of indirect N_2O emissions from N fertilizer was assessed based on the uncertainty of the emission factor (see the *2006 IPCC Guidelines*, p.11.24) and that of the amount of fertilizer. The uncertainty of indirect N_2O emissions from N mineralization associated with loss of soil organic matter was 288% the same value as the uncertainty of in direct N_2O emissions from N mineralization associated with loss of soil organic matter. Consequently, the uncertainty of indirect NO_2 emissions from this category was assessed as -118%~+286%.

- ***Time-series Consistency***

The emission factor is constant throughout the time series. For activity data, the same sources are used throughout the time series. Time-series consistency for this category is ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Since N-N_2O emission factor for soils were revised, the emissions from FY1990 to FY2013 were recalculate. Since *Yearbook of Fertilizer Statistics (Pocket Edition)* was updated, the emissions in FY2013 were revised. For the impact of the recalculation, refer to Chapter 10.

f) Category-specific Planned Improvements

None.

6.16. Biomass burning (4.(V))

a) Category Description

This category deals with emissions of CH_4, CO, N_2O and NOx from biomass burning. For the emissions of CO and NO_X, see Annex 3.

For forest land, the emissions resulting from wildfires in forest land remaining forest land and land converted to forest land are reported in a lump for wildfires in forest land remaining forest land, because the data in the statistics for forest fires include the wildfires occurred in both of the categories. Moreover, controlled burning activities in forests and land conversion from land-use categories other than forest land to forest land are not implemented in Japan because the activities are stringently restricted by the “Waste Management and Public Cleansing Act” and “Fire Service Act”. Hence, the emissions resulting from controlled burning in forest land do not occur and are reported as “NO”.

CH_4 and N_2O emissions from controlled burning in cropland are estimated for pruned branches from orchard trees. One of the characteristics of Japan’s cropland is intensive management. Under this management style, the occurrence of wildfire is regarded as negligibly small. CH_4 and N_2O emissions from wildfires in cropland are reported as “NO”.

CH_4 and N_2O emissions from wildfires in land other than forest land and cropland are reported as “NE” because information on wildfires is not sufficiently collected. CH_4 and N_2O emissions from biomass burning in river location are reported as “NE” because it can be considered insignificant.

CO_2 emission is not included in this category because it was included in estimation of carbon stock changes.

The emissions by this subcategory in FY2014 were 46.3 kt-CO_2 eq. This represents a decrease of 8.8% below the FY1990 value and an increase of 76.6% over the FY2013 value. These variations originate from the long term decreasing trend of burning amount of pruned branches from orchard trees and inter-annual variability of wild fire occurred in forest land.

Table 6-61 Non-CO_2 emissions from biomass burning

Gas	Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
All	Total	kt-CO_2 eq.	42.5	39.9	36.2	36.1	27.2	26.4	51.2	34.1	28.1	29.3	24.2	26.2	46.3
CH_4	Total	kt-CH_4	1.4	1.3	1.2	1.2	0.9	0.8	1.7	1.1	0.9	0.9	0.8	0.8	1.6
		kt-CO_2 eq.	34.2	32.3	29.3	29.5	21.3	20.6	43.6	27.8	22.3	23.5	18.8	20.7	39.3
	Forest land	kt-CH_4	0.4	0.4	0.4	0.4	0.1	0.1	1.0	0.4	0.2	0.3	0.1	0.2	0.9
	Cropland	kt-CH_4	1.0	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Grassland	kt-CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
	Wetlands	kt-CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
	Settlements	kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land	kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other	kt-CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	Total	kt-N_2O	0.028	0.026	0.023	0.022	0.020	0.020	0.026	0.021	0.019	0.020	0.018	0.018	0.023
		kt-CO_2 eq.	8.298	7.646	6.961	6.652	5.931	5.823	7.650	6.295	5.781	5.823	5.391	5.492	6.965
	Forest land	kt-N_2O	0.003	0.003	0.003	0.003	0.001	0.001	0.007	0.003	0.001	0.002	0.001	0.001	0.006
	Cropland	kt-N_2O	0.025	0.023	0.021	0.019	0.019	0.019	0.019	0.018	0.018	0.018	0.018	0.017	0.017
	Grassland	kt-N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
	Wetlands	kt-N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
	Settlements	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land	kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other	kt-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) Methodological Issues

1） Non CO_2 gases from forest fires

- ***Estimation Method***

For CH_4, and N_2O emissions due to biomass burning from forest fires, the Tier 1 method is used in the *2006 IPCC Guidelines*.

➢ ***Forest land***

- ***(CH_4)***

$$bbGHG_f = L_{forestfires} \times ER$$

- ***(N_2O)***

$$bbGHG_f = L_{forestfires} \times ER \times NC_{ratio}$$

$bbGHG_f$: GHG emissions due to forest biomass burning
$L_{forest\ fires}$: Carbon released due to forest fires [t-C/yr]
ER : Emission ratio (CH_4 : 0.012、N_2O : 0.007)
NC_{ratio} : Nitrogen Carbon ratio of the biomass

- ***Parameters***

➢ ***Emission ratio***

The following values are applied to emission ratios for non-CO_2 gases due to biomass burning.

CH_4: 0.012, N_2O: 0.007

(Default value stated in the *GPG-LULUCF*, Table 3A.1.15)

➢ ***NC ratio***

The following values are applied to NC ratio.

NC ratio: 0.01 (default value stated in the *GPG-LULUCF* p.3.50)

- ***Activity Data***

➢ ***Forest land***

As activity data in forest land, carbon released due to forest fire is used. Carbon released due to forest fire is estimated by the Tier 3 method in the *2006 IPCC Guidelines*. For each of the national forest land and private forest land, carbon emissions are calculated from the fire-damaged timber volume multiplied by wood density, the biomass expansion factor and the carbon fraction of dry matter.

$$L_{forestfires} = \Delta C_i + \Delta C_c$$

$L_{forest\ fires}$: carbon emissions due to fire [t-C/yr]
ΔC_{fn} : carbon emissions due to fire in national forests [t-C/yr]
ΔC_{fP} : carbon emissions due to fire in private forests [t-C/yr]

Biomass stock change due to fires is separately estimated for national forests and private forests. With regard to national forests, the timber volume of standing trees damaged due to fires in national forests in the *Handbook of Forestry Statistics* is used. With regard to private forests, the damaged timber volume due to fires is estimated by using the actual damaged area and damaged timber volume by age class (inquiry survey by Forestry Agency). Damaged timber volume for age class equal to or under 4 is calculated by multiplying the stand volume per unit area of age class equal to or under 4 estimated by the Forestry Status Survey and the NFRDB by loss ratio (ratio of damaged timber volume to stand volume) of age class equal to or over 5 in private forests. The loss ratio is assumed to be constant regardless of age class.

- ***National forest, Private forest***

$$\Delta C_{fn,p} = Vf_{n,p} \times D_{n,p} \times BEF_{n,p} \times CF$$

$\Delta C_{fn,p}$: carbon emissions due to fire in national forests and private forest [t-C/yr]
$Vf_{fn,p}$: damaged timber volume due to fire in national forests and private forest [m^3/yr]
$D_{n,p}$: wood density in national forests and private forest [t-d.m./m^3]
$BEF_{n,p}$: biomass expansion factor for national forests and private forest
CF : carbon fraction of dry matter [t-C/t-d.m.]

The values for wood density and biomass expansion factors for national and private forest land are determined as weighted averages using the ratios of intensively managed forests and semi-natural forests.

Table 6-62 Wood density and biomass expansion factors for national and private forests

Type	Wood density [t-d.m./m^3]	Biomass expansion factor
National forest	0.49	1.61
Private forest	0.46	1.61

Source: Based on Forestry Agency data

Table 6-63 Damaged timber volume due to wild fire

Category			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Damaged timber volume due to disturbance in national forest			m^3	3,688	1,014	1,599	359	35	969	1,901	976	16,091	934	360	279	5,386
Damaged timber volume due to disturbance in private forest			m^3	63,602	68,361	60,228	72,575	19,391	15,226	170,730	67,417	15,810	41,537	12,269	26,619	148,093
	≧5	Actual damaged area	kha	0.29	0.94	0.48	0.35	0.19	0.15	0.57	0.37	0.07	0.59	0.10	0.18	0.53
		Damaged timber volume	m^3	47,390	58,129	54,487	59,235	17,555	11,930	119,900	55,628	12,780	40,477	11,566	25,204	137,078
	≦4	Actual damaged area	kha	0.27	0.51	0.16	0.27	0.07	0.14	0.85	0.28	0.06	0.07	0.03	0.04	0.18
		Damaged timber volume	m^3	16,212	10,232	5,741	13,340	1,836	3,296	50,830	11,789	3,030	1,060	703	1,414	11,015

Source: Based on *Handbook of Forestry Statistics* for national forest, and Forestry Agency data for private forest

- ***Note***

In Japan, emissions due to biomass burning are estimated separately for national forests and for private forests, because of different reporting procedures in regards to forest fire information. However, forest fires in Japan are covered by a set of data for both national forests and private forests, and the emissions are thus appropriately estimated.

2） Non CO_2 from burning of pruned branches from orchard trees

- ***Estimation Method***

For CH_4 and N_2O emissions due to biomass burning of pruned branches from orchard trees, the estimation method (Equation 2.27, p2.42, Vol.4) described in the *2006 IPCC Guidelines* was applied. The estimation equation is as follows:

$$L_{fire} = W_B \times C_f \times G_{ef} \times 10^{-6}$$

L_{fire} : Amount of greenhouse gas emission form fire [kt- GHG]
W_B : Amount burnt [t-d.m.]
C_f : Combustion factor
G_{ef} : Emission factor [t/kt-d.m.]

- ***Parameters***

For the combustion factor, a value of 0.9 which has been used generally in field burning of crop residues in agriculture in Japan is applied. For emission factor, the default emission factors of "Agricultural residue" provided in the *2006 IPCC Guidelines* are used.

Table 6-64 Emission factors [t/kt-d.m.]

Category	CO	CH_4	N_2O	NOx
Agricultural residue	92	2.7	0.07	2.5

2006 IPCC Guidelines, Vol.4, chp.2, Table 2.5

- ***Activity Data (Amount burned)***

The amount burned data was calculated by multiplying the orchard area identified in *Cultivated and Planted Area* by the MAFF by dry matter residue weight per unit area (400kg/10a) from the domestic field survey in 1982, and ratio burned in field (25%) from the survey result in 2008.

$$W_B = (\sum_i A_i \times E \times 10) \times R$$

W_B : Amount of burning pruned branches from orchard trees [kg-d.m.]
A : Cultivation area of orchard tress [ha]
E : Dry matter residue weight per unit area [kg-d.m./10a]
R : Combustion ratio of pruned branches from orchard trees
i : Type of orchard tree

3） Non CO_2 from biomass burning in river location

Controlled burning and wildfire occur in river location in Japan, non CO_2 emissions from biomass

burning in river location are reported as "NE" because it can be considered insignificant as a result of the estimation from the number of controlled burning and wildfire, and the default values of all savanna and grass land (Tier 1) described in the *2006 IPCC Guidelines.*

c) Uncertainties and Time-series Consistency

- ***Uncertainly Assessment***

The uncertainties for parameters and activity data related to forest fires were individually assessed on the basis of field studies, expert judgment, or default values described in the *2006 IPCC Guidelines*. Regarding the uncertainties for parameters and activity data related to biomass burning for pruned branches from orchard trees, the uncertainties (CH_4: 296%, N_2O: 300%) for crop residues burning in the agriculture sector were substituted. As a result, the uncertainty estimates for the emissions resulting from biomass burning were 34% for CH_4 and 75% for N_2O, respectively.

- ***Time-series Consistency***

Time-series consistency for biomass burning in forest land remaining forest land is ensured by using the same data sources (*Handbook of Forestry Statistics* compiled by the Forestry Agency, and the data provided by the Agency) and the same methodology from 1990 to 2013. Time-series consistency for biomass burning for pruned branches from orchard trees is ensured by using the same data sources (*Statistics of Cultivated and Planted Area* by the MAFF.)

d) Category-specific QA/QC and Verification

General inventory QC procedures have been conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

There have been no source-specific recalculations

f) Category-specific Planned Improvements

None.

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Chapter 7. Waste (CRF sector 5)

7.1. Overview of Sector

7.1.1. Overview of Waste Management and Estimation Category

In the waste sector, greenhouse gas emissions from treatment and disposal of waste are estimated for solid waste disposal (5.A.), biological treatment of solid waste (5.B.), incineration and open burning of waste (5.C.), wastewater treatment and discharge (5.D.), and other (5.E.)[1] in accordance with treatment processes. Figure 7-1 and Figure 7-2 show the estimation categories of waste/wastewater treatment system and/or waste classification in Japan.

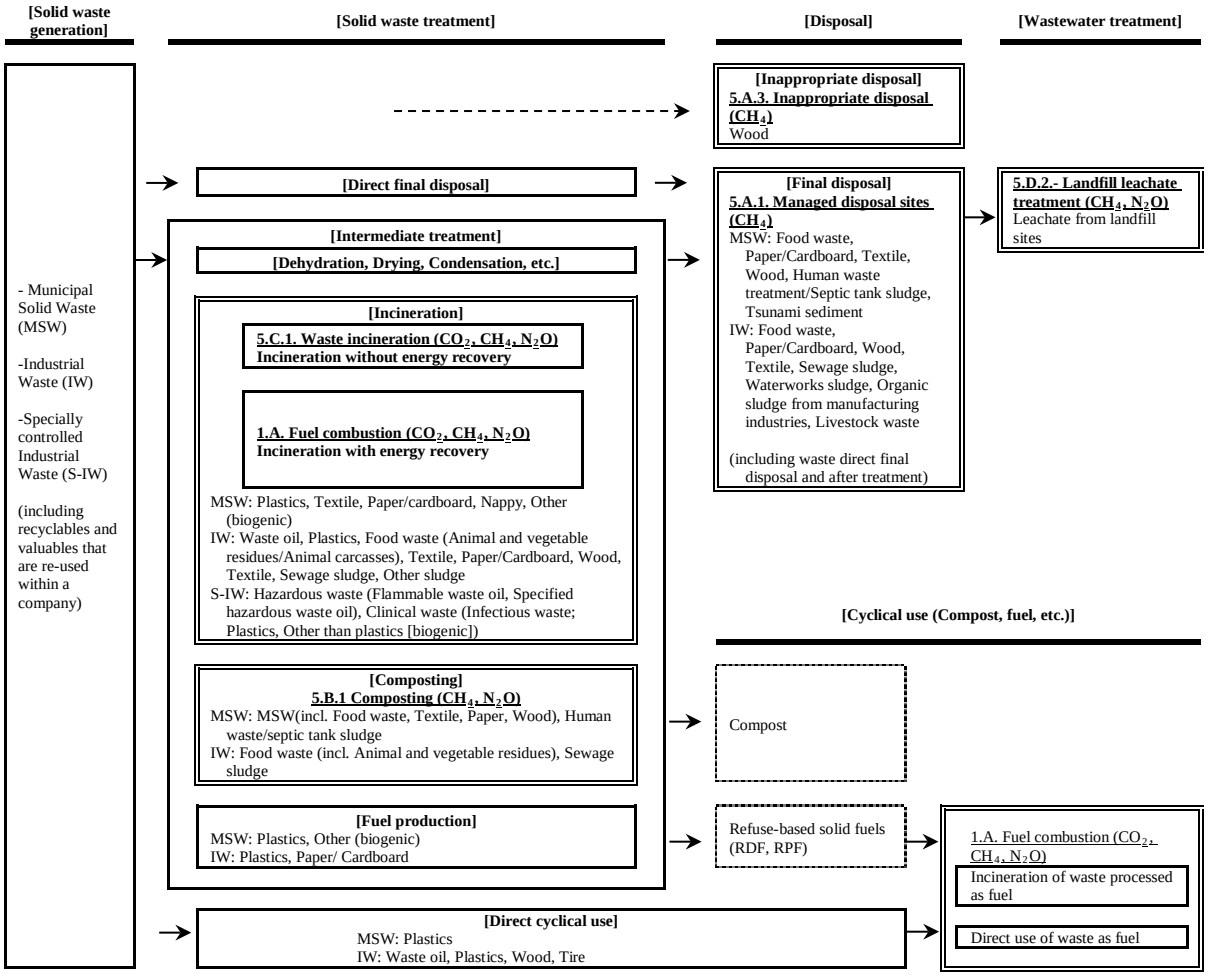

Figure 7-1 Flow chart of solid waste managements and the estimation categories

[1] Data for some emission source categories in the waste sector are complemented by estimation, when statistical data or related data are not available. The methodologies for this estimation are not described in this chapter. For details, refer to the *Report of the Waste Panel on Greenhouse Gas Emission Estimate (2006)* (hereinafter referred to as Reference #7) and the website of the Ministry of the Environment, *Review of Greenhouse Gases Emissions Estimation Methods* (http://www.env.go.jp/earth/ondanka/santeiho/kento/index.html).

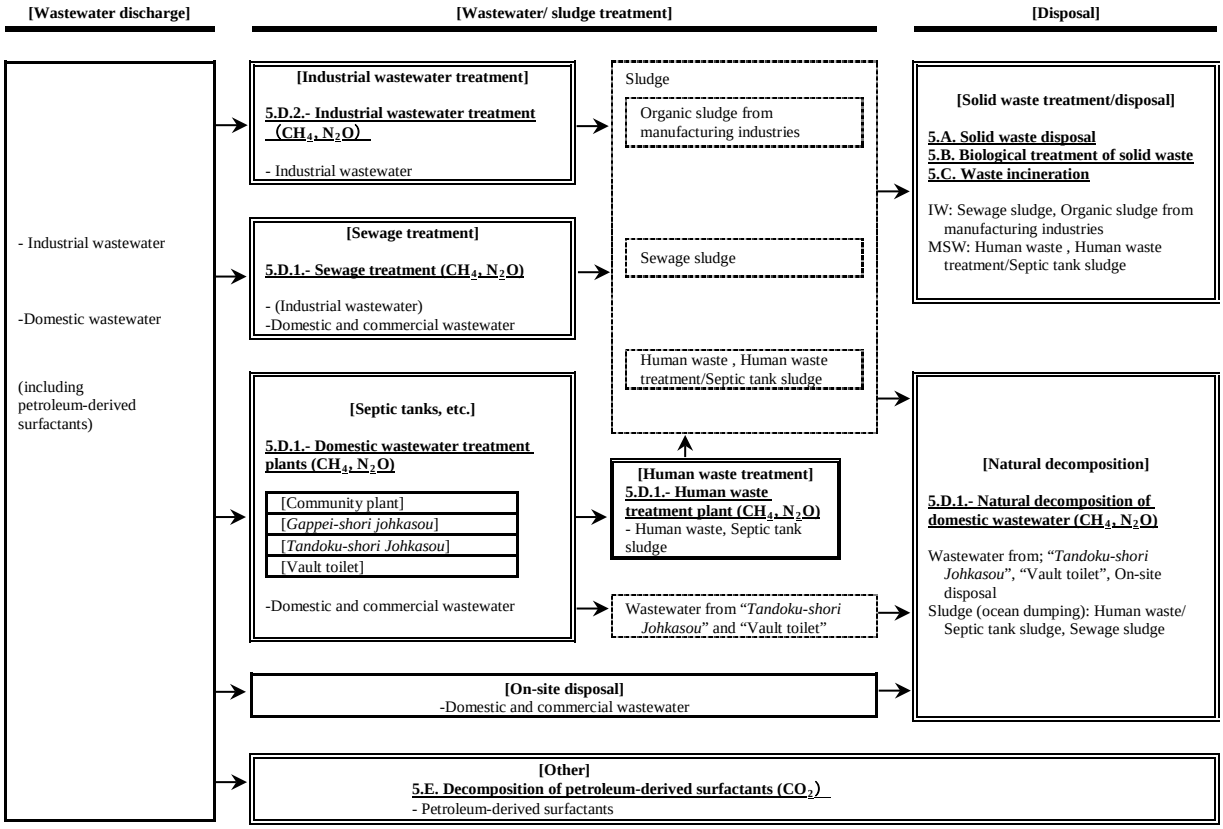

Figure 7-2 Flow chart of wastewater/sludge treatments and the estimation categories

Waste to be covered in this sector is the waste as defined in the *2006 IPCC Guidelines*. In the case of Japan, the waste does not only include municipal waste and industrial waste as defined by the Waste Disposal and Pubic Cleansing Law, but also recyclables and valuables that are re-used within a company. Since waste statistics are compiled separately for municipal waste and industrial waste in Japan, estimation methodologies for many of emission sources in the waste sector are discussed respectively for municipal waste and industrial waste. Emissions from the treatment of disaster waste caused by the Great East Japan Earthquake, which occurred on 11th March, 2011, are reported in this sector.

7.1.2. Overview of Greenhouse Gas Emissions on Waste Sector

In FY2014, emissions from the Waste sector resulted in 21,142 kt-CO_2 eq. and accounted for 1.6% of Japan's total greenhouse gas emissions (excluding LULUCF). Total emissions had decreased by 25.0% compared to those of FY1990 and decreased by 1.2% compared to those of FY2013. Breakdown of FY2014 emissions of the Waste sector by category shows that the largest contributor to the emissions is Incineration and Open Burning of Waste (5.C.) (excluding emissions with energy recovery, emissions from direct use of waste as fuel, and emissions from incineration of waste processed as fuel) accounting for 65.2% (an decrease by 0.6% from FY1990) followed by the Solid Waste Disposal (5.A.) accounting for 15.7% (a decrease by 64.1% from FY1990), Wastewater Treatment and Discharge (5.D.) accounting for 13.3% (a decrease by 30.9% compared to FY1990), Other (5.E.) accounting for 2.9% (a decrease by 12.3% from FY1990) , and Biological Treatment of Solid Waste (5.B.) accounting for 2.9% (an increase by 82.4% from FY1990). Breakdown of the

emissions of the Waste sector by gas shows that the largest contributor to the emissions is CO_2 emissions associated with the incineration of petroleum-derived waste such as waste plastic and waste oil accounting for 58%, followed by CH_4 emissions from solid waste disposal on land accounting for 16%, CH_4 emissions from wastewater treatment and discharge accounting for 8%.

The changes in greenhouse gas emissions from the Waste sector since FY1990 show a trend in a decrease in CH_4 emissions from the solid waste disposal on land associated with a decrease in the amount of disposal of biodegradable waste and a decrease in CO_2 emissions from the incineration of petroleum-derived waste due to the improvement in recycling rate since the enactment of the Basic Law for Establishing the Recycling-based Society and other recycling laws. On the other hand, emissions from the incineration of petroleum-derived waste with energy recovery, emissions from the direct use of petroleum-derived waste as raw material and fuel, and emissions from the incineration of petroleum-derived waste processed as fuel, which are accounted for in the Energy sector, have increased along with an increase of waste recycling rate (an increase by 44.5% from FY1990).

7.1.3. General Description for Methodological Issues on the Waste Sector

- ***Estimation Method and Emission Factors***

Japan generally employs country specific methodologies and emission factors in GHG emission estimations on the waste sector. For the category on which sufficient views are not obtained from domestic survey, default methodologies and emission factors in the *2006 IPCC Guidelines* are partially applied. For details, see articles "*b) Methodological Issues*" in each category's section.

Table 7-1 Summary for methods and emission factors used on waste sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O	
	Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
5. Waste	CS	CS	CS,D,T1,T3	CS,D	CS,D,T1	CS,D
A. Solid waste disposal	NA	NA	T3	CS		
B. Biological treatment of solid waste			D,T1	D	D,T1	D
C. Incineration and open burning of waste	CS	CS	CS	CS	CS	CS
D. Waste water treatment and discharge			CS,D	CS,D	CS,D	CS,D
E. Other	CS	CS	NA	NA	NA	NA

D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country specific method or EF

- ***Activity Data***

As activity data in the methodologies on the waste sector, the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes (Volume on Cyclical Use)*, Waste Management and Recycling Department of the Ministry of the Environment (hereinafter referred to as the *Cyclical Use of Waste Report*), the *Waste Treatment in Japan*, the same agency (hereinafter referred to as the *Waste Treatment in Japan*), and the *annual editions of Sewage Statistics (Admin. Ed.)*, Japan Sewage Works Association (hereinafter referred to as the *Sewage Statistics*) are mainly referred. Also, various other statistics related on the waste management and provided data from relevant agencies and bodies are used. For details, see articles "*b) Methodological Issues*" in each category's section.

7.1.4. General Assessment Procedure for the Uncertainty on the Waste Sector

The uncertainty of GHG emissions on the waste sector is assessed based on the *2006 IPCC guidelines* and *The guideline of uncertainty assessment for National GHG inventories*, Ministry of the Environment (Reference #22). The general assessment procedures are indicated below. For details, see articles "*c) Uncertainties and Time-series Consistency*" in each category's section.

- ***Emission factors***

The uncertainties in emission factors are assessed by using the 95% confidence interval obtained from actual measurement, or by expert judgment. When emission factor is derived from formulas using parameters, the uncertainty is assessed by combining the uncertainties of these parameters.

- ***Activity data***

Regarding the uncertainty for activity data, due to the lack of information on statistical error in quoted references, it is difficult to assess uncertainties based on concrete evidence. Therefore, it is assessed by expert judgment as indicated in the Table 7-2.

Table 7-2 Uncertainty for statistics used for activity data on waste sector

Statistics used for activity data	Range of uncertainty		Justification for assessing the uncertainty
	(-)	(+)	
Municipal waste (Domestic wastewater excluding sewerage)	-10%	+10%	In the uncertainty which is provided as default value in the *2006 IPCC guidelines*, the value (±10%) in the case where waste weight is measured by truck scale is adopted based on expert judgment.
Industrial waste (Industrial wastewater)	-30%	+30%	In the uncertainty which is provided as default value in the *2006 IPCC guidelines*, the value (±30%) "in the case where amount of generated waste is regularly collected" is adopted based on expert judgment.
Specially-controlled industrial waste	-60%	+60%	The twofold higher uncertainty than the value in industrial waste statistics is adopted based on expert judgment.
Valuables (valuable waste)	-30%	+30%	In the uncertainty which is provided as default value in the *2006 IPCC guidelines*, the value (±30%) "in the case where amount of generated waste is regularly collected" is adopted based on expert judgment.
Sewage	-5%	+5%	Since the data has collected through complete survey for whole domestic sewage treatment plants, it is considered that data is accurate enough to reflect the current status. Therefore, the uncertainty is evaluated at 5% based on expert judgment.
Water works	-5%	+10%	Sampling error in the statistics is evaluated at 5% based on expert judgment as well as sewage statistics. However, water works statistics target only water company and supplier of city water which have more than 5001 official water supplied population; sludge generated from small-sized filter plants by private water-supply system is not identified. Therefore, an additional 5% to the upper limit of uncertainty is added since the population of private water-supply system account for 5% of the total.

- ***Emissions***

Since emissions are calculated by formulas, the uncertainty is assessed by combining the uncertainties of emission factors and activity data.

7.1.5. General Recalculations for Emissions from Waste Sector

Furthermore, due to the fact that most of statistics used for emission estimates in the Waste sector are produced on the basis of Japan's fiscal year (starting on April 1 of the year and ending on March 31 of the following year), and the whole process of statistical compilation for the latest fiscal year does not complete in time for an inventory compilation, preliminary data are applied for the activity data of the latest reporting year. Consequently, every year, these preliminary data are updated with definite data, and emission estimates are recalculated in the inventory of its next annual submission.

7.2. Solid Waste Disposal (5.A.)

This category covers CH_4 emissions from solid waste disposal on land. For this emission source category, estimation methodologies are discussed separately for municipal waste and industrial waste

in accordance with Japan's waste classification system, and emissions are estimated for the sources presented in Table 7-3.

Table 7-3 Categories whose emissions are estimated for solid waste disposal (5.A.)

Category	Waste type				Disposal type		CO_2	CH_4
5.A.1. (7.2.1)	Municipal solid waste	Food waste			Managed disposal sites	Anaerobic/ Semi-aerobic landfill	NO	○
		Paper/ cardboard						○
		Wood						○
		Textiles	Natural fiber [1]					○
		Sludge	Human waste treatment, Septic tank sludge					○
			Tsunami sediment [2]			Anaerobic landfill [7]	NO	○
	Industrial waste	Food waste [3]	Animal and vegetable residues, Animal carcasses			Anaerobic/ Semi-aerobic landfill	NO	○
		Paper/ Cardboard						○
		Wood						○
		Textiles	Natural fiber [1]					○
		Sludge	Sewage sludge	Digested sewage sludge [4]				○
				Other sewage sludge				○
			Waterworks sludge					○
			Organic sludge from manufacturing industries					○
			Livestock waste [5]					○
5.A.2. (7.2.2)						Unmanaged disposal sites	NO	NO
5.A.3. (7.2.3)	Wood					Inappropriate disposal [6] (Anaerobic landfill)	NE	○

Note:

1) Only natural fiber textiles are included in the estimation under the assumption that synthetic fiber waste is not biologically decomposed in landfills.
2) Part of tsunami sediment generated by the Great East Japan Earthquake, which occurred on 11th March, 2011, is disposed of finally. Since disposed tsunami sediment includes organic matters, CH_4 emissions from this source are estimated using the emission factor for wood by expert judgment.
3) Japan's industrial waste classifications of "Animal and vegetable residues" and "Animal carcasses" are aggregated as food waste.
4) "Digested sewage sludge" includes sewage sludge landfilled after digested and dehydrated. Because digestion treatment reduces the amount of carbon content biodegraded in sludge decreases, CH_4 emissions are estimated separately by landfilled sewage sludge with and without digestion treatment.
5) Although livestock waste is not classified as "sludge" under Japanese law, emissions from it are estimated within the category of sludge because of the similarities in their properties.
6) The emissions from wood are currently considered as inappropriate disposal of waste containing biodegradable carbon.
7) Since the condition of tsunami sediment disposed of is not identified, it is conservatively assumed as anaerobic landfill.

Table 7-4 GHG emissions from solid waste disposal (5.A.)

Gas	Category			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	5.A.1. Managed waste disposal saites	a. Anaerobic landfill		kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Semiaerobic landfill		kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	5.A.2. Unmanaged waste disposal sites			kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	5.A.3. Uncategorized waste disposal sites	Inappropriate disposal		kt-CO_2	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Total			kt-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
CH_4	5.A.1. Managed waste disposal saites	a. Anaerobic landfill	MSW	kt-CH_4	218.0	187.2	145.3	110.2	103.8	98.0	90.9	85.3	79.6	74.6	70.0	65.7	61.9
			ISW	kt-CH_4	127.8	121.4	99.0	68.9	63.2	58.0	53.2	48.9	45.0	41.9	39.4	36.8	35.2
		b. Semiaerobic landfill	MSW	kt-CH_4	18.7	28.0	31.8	34.6	34.3	33.7	32.0	30.4	28.6	27.2	26.1	25.4	24.2
			ISW	kt-CH_4	3.9	7.3	11.0	12.0	11.6	11.2	10.4	9.8	9.0	8.7	8.7	8.7	9.5
	5.A.2. Unmanaged waste disposal sites			kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	5.A.3. Uncategorized waste disposal sites	Inappropriate disposal		kt-CH_4	0.3	0.8	2.4	2.4	2.4	2.3	2.1	2.0	2.0	2.0	2.0	1.9	1.7
	Total			kt-CH_4	368.8	344.8	289.4	228.1	215.3	203.2	188.7	176.5	164.3	154.5	146.2	138.4	132.5
				kt-CO_2 eq.	9,221	8,619	7,236	5,703	5,383	5,080	4,717	4,413	4,107	3,861	3,655	3,459	3,314
Total				kt-CO_2 eq	9,221	8,619	7,236	5,703	5,383	5,080	4,717	4,413	4,107	3,861	3,655	3,459	3,314

Estimated greenhouse gas emissions from solid waste disposal on land are shown in Table 7-4. In FY2014, greenhouse gas emissions from this source category are 3,314 kt-CO_2 eq. and accounted for 0.2% of the national total emissions (excluding LULUCF). Emissions from this category decreased by 64.1% compared to the emissions in FY1990. This CH_4 emissions decrease is the result of decrease in the amount of biodegradable waste landfilled due to the increase in the practice of waste incineration to reduce waste volume in Japan.

7.2.1. Managed Disposal Sites (5.A.1.)

a) Category Description

In Japan, part of food waste, paper/cardboard, textiles, wood, and sludge in municipal solid waste (MSW) and industrial waste (IW) is landfilled without incineration; therefore, CH_4 is generated as a result of biodegradation of organic materials from the landfill sites. Because Japanese landfill sites are appropriately managed pursuant to the Waste Disposal and Public Cleansing Law, the amount of CH_4 emitted from there is reported under this category "Managed Disposal Sites (5.A.1.)". Emissions of CO_2 from waste incineration at the managed disposal sites are reported as NO, because waste incineration is not implemented at that site in Japan.

b) Methodological Issues

- ***Estimation Method***

The revised first order decay (FOD) method given in the *2006 IPCC Guidelines* is applied for its emission estimates since this method assumes the delay time from the deposition of waste to the generation of CH_4. According to the decision tree indicated in the said guidelines, the revised FOD method with country-specific parameters (Tier 3) is used to estimate emissions from this source.

In Japan, emission factor is defined as "CH_4 emissions from biodegradable waste", and activity data are defined as "the amount of waste biodegraded within the reporting fiscal year".

$$E_i = \left\{ \sum \left(EF_{ij} \times A_{ij} \right) - R \right\} \times \left(1 - OX \right)$$

Where :

Ei	: CH_4 emissions from landfill sites [kg-CH_4]
$EF_{i,j}$	: Emission factor for a biodegradable waste i (dry basis) that is damped into a landfill site j without incineration [kg-CH_4/t]
$A_{i,j}$	: Amount of a biodegradable waste i (dry basis) that is damped into a landfill site j without incineration and is biodegraded within an inventory year) [t]
R	: Recovered CH_4 in an inventory year [kg-CH_4]
OX	: Oxidation factor of CH_4 related to soil cover

- ***Emission Factors***

Emission factors are defined as the amount of CH_4 [kg] generated through decomposition of one ton of biodegradable landfill wastes (dry basis) without incineration. They are established by the type of biodegradable waste (i.e., food waste, paper/cardboard, natural fibers, wood, sewage sludge, human waste, waterworks sludge, organic sludge from manufacturing industries and livestock waste) and by the type of landfill site (i.e., anaerobic or semi-aerobic landfill). Emission factors are estimated as indicated below.

CH_4 Emission factor

$$EF_{iCH4} = DOCi \times DOCF \times MCF \times F \times 1000 \times 16/12$$

DOC_i : Fraction of carbon content

$DOCF$: Fraction of degradable organic carbon dissimilated

MCF : Methane correction factor

F : Percentages of CH_4 in landfill gas

- ***Carbon Content (Per Dry Weight)***

Carbon content per dry weight, which is used as uniform value every year because the property of each waste type does not vary significantly over time, is determined based on the "*Ministry of the Environment, Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, 2010*" (hereinafter referred to as Reference #18) and Reference #7 as indicated in Table 7-5 below.

Table 7-5 Carbon content of waste disposed of in managed landfill sites (dry basis)

Item	Carbon Content [%]	Data source
Food waste	43.4	MSW: Calculated by taking the averages of carbon contents of MSW provided by Tokyo, Yokohama, Kawasaki, Kobe, and Fukuoka (FY1990-2004) IW: Substituted the carbon content of MSW for IW because its properties are similar to those of MSW (Reference #18)
Paper/ Cardboard	40.9	
Wood	45.2	
Textiles (natural fiber)	45.0	Calculated by taking a weighted average of carbon content estimated based on the constituent of each natural fiber type (cotton, wool, silk, linen, and recycled textiles) by the domestic demand of natural fibers (FY1990-2004) (Reference #7)
Human waste treatment, Septic tank sludge	40.0	Substituted the value for "Other sewage sludge"
Tsunami sediment	4.5	Calculated by multiplying the fraction of organic matter in tsunami sediment by the fraction of carbon contents in the organic matter; assuming the fraction of organic matter in tsunami sediment finally disposed of is 10%, and 45.2% of fraction of carbon content for wood is substituted for tsunami sediment by expert judgment
Digested sewage sludge	30.0	Expert judgment based on Fujimoto (2000), Fujishima, et al. (2004), Oshima, et al. (1986) and Tanaka, et al. (1980) (Reference #59, 61, 69, 74)
Other sewage sludge	40.0	Expert judgment based on domestic researches (Reference #7)
Waterworks sludge	6.0	Average values of survey results conducted at 23 water purification plants (Reference #18)
Organic sludge from manufacturing	45.0	Value for papermaking industry is substituted because it generates the largest amount of organic sludge finally disposed of. Estimated based on the carbon content of cellulose because the main constituent of organic sludge generated is paper sludge (Reference #7)
Livestock waste	40.0	Substituted the value for "Other sewage sludge"

- ***Fraction of degradable organic carbon dissimilated***

Fraction of degradable organic carbon dissimilated for the biodegradable waste is set at 50% based on Ito (1992) (Reference #63).

- ***Methane Correction Factor (MCF)***

- ***Anaerobic landfill sites***

For Methane Correction Factor of anaerobic landfill sites (MCF_{an}), default values of 1.0 given in the *2006 IPCC Guidelines* is used.

- ***Semi-aerobic landfill sites***

For Methane Correction Factor of semi-aerobic landfill sites in ideal condition (MCF_{semi}) default values of 0.5 given in the *2006 IPCC Guidelines* is used. However, semi-aerobic landfill site in Japan is in an anaerobic condition when the outflow port of leachate collection system is swamped, the system is full of water, it holds retaining of leachate, or leachate collection/gas extraction system is not properly extend. Considering these inappropriate management conditions of the leachate collection system at landfill sites, a country-specific parameter is defined as "percentage of open outflow port of leachate collection system" and used for the estimation; the methane correction factor of semi-aerobic landfill site in actual condition ($MCF_{semi,act}$) is estimated for municipal solid waste disposal sites and industrial waste disposal sites, respectively, as follows:

$$MCF_{semi,act} = \{P \times MCF_{semi} + (1 - P) \times MCF_{an}\}$$

$MCF_{semi,act}$: Methane correction factor of semi-aerobic landfill sites in actual condition
MCF_{semi} : Methane correction factor of semi-aerobic landfill sites in ideal condition (0.5)
MCF_{an} : Methane correction factor of anaerobic landfill sites (1.0)
P : Percentage of open outflow port of leachate collection system

Where,

$$P = W'/W$$

W' : Disposal amount in a reporting year at semi-aerobic landfill sites in ideal condition, where open outflow port of leachate collection system [for municipal solid waste: t, for industrial waste: m^3]
W : Disposal amount in a reporting year at whole semi-aerobic landfill sites [for municipal solid waste: t, for industrial waste: m^3]

To evaluate W' and W for municipal solid waste, the condition of open outflow port and disposal amount in each semi-aerobic landfill sites provided in "*The state of municipal waste treatment survey*" are used. For industrial waste, those data in each semi-aerobic landfill sites indicated in a result of questionnaire survey by Ministry of the Environment, Waste Management and Recycling Department, are used.

Table 7-6 Percentage of open outflow port of leachate collection system at semi-aerobic landfill sites for municipal solid waste and industrial waste

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Municipal solid	%	64.7	64.7	64.7	64.7	64.7	65.5	64.7	66.7	69.1	71.2	71.2	69.7	69.7
Industrial solid waste	%	57.9	57.9	57.9	57.9	57.9	57.9	57.3	57.9	55.9	57.2	57.2	57.2	57.2

- ***Proportions of CH_4 in Generated Gas***

Default value (50%) given in the *2006 IPCC Guidelines* is used.

- ***Emission Factor***

Emission factors calculated by methodologies above are shown in Table 7-7.

Table 7-7 Emission factors by type of biodegradable waste and by treatment

Item	Anaerobic landfill [kg-CH_4/t]	Semi-aerobic landfill [1)] [kg-CH_4/t]
Food waste	145	72
Paper/ Cardboard	136	68
Textiles	150	75
Wood	151	75
Human waste treatment, Septic tank sludge	133	67
Tsunami sediment	15	NA
Digested sewage sludge	100	50
Other sewage sludge	133	67
Waterworks sludge	20	10
Organic sludge from manufacturing	150	75
Livestock waste	133	67

1) Each emission factor indicated in the table are the values in the ideal condition of semi-aerobic landfill. (MCF=0.5).

- ***Activity Data***

Out of the amount of waste landfilled without incineration (dry basis), the amount of waste degraded within the reporting year is calculated by multiplying the amount of waste remaining in landfills at the end of the previous reporting year by the methane generation rate constant for waste landfilled. The amount of biodegradable MSW and IW are determined by type of waste and landfill site.

The amount of waste landfilled in each fiscal year is calculated by multiplying the amount of biodegradable waste landfilled (wet basis) by the percentage of landfill site by the type of site (wet basis), and subtracting the water content by each type of waste. Activity data are estimated going back as far as FY1954, when the Public Cleansing Law (now the Waste Disposal and Public Cleansing Law) was enforced.

$$W_i(T) = W_i(T-1) \times e^{-k} + w_i(T)$$
$$A_i(T) = W_i(T-1) \times \left(1 - e^{-k}\right)$$
$$k = \ln(2) / H$$

Where:

$A_i(T)$: Amount of waste *i* degraded in the calculated year (year T) (activity data: dry basis)
$W_i(T)$: Amount of waste *i* remaining in a landfill in year T
$w_i(T)$: Amount of waste *i* landfilled in year T
k : Methane generation rate constant [1/year], and
H : Decomposition half-life of waste *i* (the time taken by landfilled waste *i* to reduce in amount by half)

The amount of waste *i* landfilled in year T
$w_i(T)$ = (Amount of biodegraded waste *i* landfilled in year T)
× (percentages of landfill sites of each site type)
× (1 - percentage of water content in waste *i*)

- ***Amount of Biodegradable Waste Disposed of in Landfills***

Table 7-8 shows the annual amount of biodegradable waste landfilled (dry basis) in Japan.

Table 7-8 Annual amount of biodegradable waste disposed of in landfills
(Total amount of anaerobic and semi-aerobic landfilling)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MSW														
Food waste	kt / year (dry)	424	272	196	78	68	29	38	30	30	27	22	21	19
Paper/ Cardboad	kt / year (dry)	1,140	859	698	492	518	270	376	300	311	294	260	226	199
Textiles (natural fiber)	kt / year (dry)	59	46	34	67	26	28	10	4	3	5	4	3	3
Wood	kt / year (dry)	363	200	155	81	87	63	53	42	40	37	31	65	25
Human waste treatment, septic tank sludge	kt / year (dry)	78	51	46	47	29	12	17	15	17	11	12	7	5
Ttsunami sediment	kt / year (dry)	NO	NO	NO	NO	NO	NO	NO	NO	NO	9	10	29	0
ISW														
Food waste	kt / year (dry)	81	221	114	57	51	36	40	36	35	41	48	19	18
Paper/ Cardboad	kt / year (dry)	73	89	69	42	43	30	11	12	3	9	3	5	9
Textiles (natural fiber)	kt / year (dry)	3	10	10	6	5	4	3	2	2	3	2	2	3
Wood	kt / year (dry)	309	326	143	114	101	62	31	36	19	39	15	24	20
Digested sewage sludge	kt / year (dry)	59	50	31	11	8	5	4	3	3	5	5	4	5
Other sewage sludge	kt / year (dry)	219	185	114	42	29	20	17	17	17	34	22	11	12
Waterworks sludge	kt / year (dry)	199	166	146	66	62	67	67	67	67	67	67	67	67
Organic sludge from manufacturing industry	kt / year (dry)	345	153	69	48	39	34	23	22	31	39	27	164	164
Livestock waste	kt / year (dry)	12	12	11	11	11	11	11	14	11	11	9	12	12

As indicated in Table 7-9, for the data sources for the amount of biodegradable waste landfilled by waste type, the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes (Volume on Cyclical Use)*, Waste Management and Recycling Department of the Ministry of the Environment (hereinafter referred to as the *Cyclical Use of Waste Report*), and the *Annual editions of Sewage Statistics (Admin. Ed.)*, Japan Sewage Works Association (hereinafter referred to as the *Sewage Statistics*) are used.

The amount of biodegradable waste landfilled is estimated going back as far as FY1954, when the Public Cleansing Law (now the Waste Disposal and Public Cleansing Law) was enforced. The statistical survey of landfilling began in 1980s, and in the case that historical data on the amount of biodegradable waste landfilled are unavailable (primarily prior to FY1980), the data of the most current year available (primarily the data of FY1980) are applied. For the years where the data are unavailable even after FY1980, interpolated values are applied. For details, see Table 7-9.

Table 7-9 Overview of data for the amount of biodegradable waste disposed of in landfill

Waste type			Data source	Detail	Extrapolation
Municipal solid waste	Food waste		*Cyclical Use of Waste Report* (MoEJ)	Calculated by multiplying total amount of corresponding landfilled waste by the composition ratio of each waste type	- Estimated by interpolation for some fiscal years, - Substituted FY1980 value for the years prior to FY1980
	Paper/ Cardboard				
	Wood				
	Textiles (natural fiber)			Calculated by multiplying by the ratio of natural fiber textiles in textile products each year from "*Annual Textile Statistics Report*"	
	Human waste treatment, Septic tank sludge	(Direct final disposal)	*Waste Management in Japan* (MoEJ)	Calculated by multiplying the amount of human waste sludge in "other treatment" (volume basis) by the weight-conversion factor (1.0 kg/L)	Substituted FY1978 value for the years prior to FY1978
		(Final disposal after treatment)	*Cyclical Use of Waste Report* (MoEJ)	"Final disposal after treatment" of "Human waste treatment and septic tank sludge" (estimated by subtracting the amount of final disposal from those incinerated within the incineration facilities or sewage sludge treatment facilities)	For the years prior to FY1998, estimated by using the amount of direct final disposal human waste sludge
	Tsunami sediment		*Waste Treatment in Japan* (MoEJ)	Direct final disposal of "Tsunami sediment"	Disposed from FY2011
Industrial waste	Food waste		*Cyclical Use of Waste Report* (MoEJ)	- Amount of animal and vegetable residues directly landfilled and after intermediate processing. - Amount of animal carcasses directly landfilled	- Estimated by interpolation for some fiscal years, - Substituted FY1980 value for the years prior to FY1980
	Paper/ Cardboard			Amount of paper directly landfilled	
	Wood			Amount of wood directly landfilled	
	Textiles (natural fiber)			Amount of natural fiber textiles directly landfilled (considering all the amount as waste natural fiber textiles due to the Waste Disposal and Pubic Cleansing Law	
	Digested sewage sludge		*Data provided by METI*	Compiled and provided by MLIT	- For some fiscal years, estimated by interpolation - Substituted FY1985 value for the years prior to FY1985
	Other sewage sludge		*Annual editions of Sewage Statistics (Admin. Ed.)*	Total amount of sewage sludge excluding the amount of digested sewage sludge	
	Waterworks sludge		*Waterworks Statistics* (Japan Water Works Association)	Estimated by "Total amount of soil disposed" and "landfilled percentage" of each purification plant	Substituted FY1980 value for the years prior to FY1980
	Organic sludge from manufacturing	Papermaking industry	Data provided by Japan Paper Association, Japan Technical Association of the Pulp and Paper Industry	Total amount of organic sludge landfilled for papermaking industry	Substituted FY1989 value for the years prior to FY1989
		Chemicals industry	*Survey of generation status of industry -specific by-products (industrial waste and recyclable waste)* (METI), etc.	Total amount of organic sludge landfilled for chemicals industry and food manufacturing industry	- For some fiscal years, estimated by interpolation - For the years prior to FY1998, estimated with the data from *Follow-up Action Result of the Voluntary Action Plan on the Environment* (Japan Business Federation) - Substituted FY1990 value for the years prior to FY1990
		Food manufacturing industry			
	Livestock waste		Survey conducted by MoEJ		Substituted FY1980 value for the years prior to FY1980

➢ *Percentage of Water Content in Waste*

In Japan, activity data are estimated on a dry basis because the carbon content of waste can be identified more precisely. The percentages of water content by each type of waste to estimate activity data on a dry basis and their sources are given in Table 7-10. In order to estimate the CO_2 emissions for the category "7.4. Incineration and Open Burning of Waste (5.C.)" as well as this source category, dry basis activity are used for the same reason.

Table 7-10 Percentage of water content in waste disposed of in managed landfill sites

Items		Water content [%]	Source
Food waste		75 (direct final disposal)	Water percentage of food waste in *Cyclical Use of Waste Report*
		30 (final disposal after treatment)	Expert judgment
Paper/ Cardboard		20 (MSW) 15 (IW)	Expert judgment
Wood		45	Expert judgment
Textiles (natural fiber)		20 (MSW) 15 (IW)	Expert judgment
Sludge from human waste treatment and septic tanks		85 (direct final disposal)	Moisture content standard of landfill standard (sludge) specified by enforcement ordinance of Wastes Disposal and Public Cleansing Law
		70 (final disposal after treatment)	Expert judgment
Tsunami sediment		45	Substituted the value for wood by expert judgment
Sewage sludge	Digested sewage sludge	Specific to each disposal site	Average moisture content of "delivered or final disposal sludge" in *Sewage Statistics (Admin. Ed.)*
	Other sewage sludge		
Waterworks Sludge		- *	―
Organic sludge from manufacturing industries		77 (food manufacturing) 57 (chemical industries) - (paper industries)*	Reference of Clean Japan Center Survey
Livestock waste		83.1 (direct final disposal)	Percentage of water content in "*Controlling the Generation of Greenhouse Gases in the Livestock Industry*"
		70 (final disposal after treatment)	Expert judgment

Note: * The water content of waterworks sludge and organic sludge from paper industries are not included in this table because activity data on a dry basis are provided by the data sources.

➢ ***Percentages of Landfill Sites by Site Structure Type***

- ***Percentages of MSW Landfill Sites by Site Structure Type***

Among the Japan's MSW disposal sites listed in the section "Facility by Type (Final Disposal Sites)" of *Annual editions of Results of Study on Municipal Solid Waste Disposal*, Waste Management and Recycling Department, Ministry of the Environment (hereinafter referred to as *Results of Study on MSW Disposal*), landfill sites which have leachate treatment facilities and subsurface containment structures are regarded as semi-aerobic landfill sites, and the percentage of their total landfill capacity [m^3] is defined as the percentage of semi-aerobic landfill disposal volume.

Since the percentages of semi-aerobic landfill sites for the period FY1996 and before are not available, they are determined as indicated below:

- For the period FY1997 and after, they are determined based on actual data.
- For the period FY1977 and before, all the landfill sites including all the sea area landfills are considered to be anaerobic landfill sites since semi-aerobic landfill technology started in FY1977.
- For the period FY1977-1996, they are estimated by linear interpolation using actual data of FY1997 based on expert judgment.

- ***Percentages of IW Landfill Sites by Site Structure Type***

The percentages of landfill sites by site structure type for IW are determined as follows:

- For the period FY2008 and after, they are determined based on the IW landfill site survey results conducted by the Ministry of the Environment.

- For the period FY1977 and before, all the landfill sites including all the sea area landfills are considered to be anaerobic landfill sites since semi-aerobic landfill technology started in FY1977.
- For the period FY1990 -2007, they are estimated by using the total amount of waste landfilled and the actual data of waste deposited of in semi-aerobic landfill sites in FY2008.
- For the period FY1977-1989, they are estimated by linear interpolation using the data of FY1990 based on expert judgment.

Table 7-11 Percentages of landfill sites by site structure

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Municipal solid waste														
Anaerobic landfill	%	74.2	64.2	54.4	43.5	41.8	40.5	41.5	36.5	36.1	38.7	33.1	39.9	39.9
Semi-aerobic landfill	%	25.8	35.8	45.6	56.5	58.2	59.5	58.5	63.5	63.9	61.3	66.9	60.1	60.1
Industrial solid waste														
Anaerobic landfill	%	90.2	81.1	66.4	48.3	46.0	45.8	45.8	36.9	47.0	36.7	28.5	30.0	30.0
Semi-aerobic landfill	%	9.8	18.9	33.6	51.7	54.0	54.2	54.2	63.1	53.0	63.3	71.5	70.0	70.0

➢ *Decomposition Half-life*

Decomposition half-life is the time taken for 50% of waste landfilled in a certain year to be degraded from its initial mass. According to Ito (1992) (Reference #63), the half-lives for food waste, paper/cardboard, textiles (natural fiber), and wood are respectively 3, 7, 7, and 36 years. Because no relevant research have been obtained to identify a country specific half-life for the sludge, the default value of 3.7 years provided in the spreadsheets attached to the *2006 IPCC Guidelines* is applied. The half-life for wood is used for the half-life of tsunami sediment as a substitute by expert judgment.

Table 7-12 Decomposition half-life for biodegradable waste

Item		Half-life [year]	Data source
Food waste		3	Ito (1992) (Reference #63)
Paper/cardboard		7	
Wood		7	
Textiles (natural fiber)		36	
Sludge	Tsunami sediment	36	The half-life of wood is applied by expert judgment
	Human waste treatment, Septic tank sludge	3.7	*2006 IPCC Guidelines*
	Digested sewage sludge		
	Other sewage sludge		
	Waterworks sludge		
	Organic sludge from manufacturing		
	Livestock waste		
	Digested sewage sludge		

➢ *Delay Time*

Delay time is the time lag from when the waste is landfilled until when the decomposition actually occurs. As no knowledge is obtained for making it possible to set a delay time specific to Japan, the default value (6 months) given in the *2006 IPCC Guidelines* is used.

Table 7-13 Amount of biodegraded waste decomposed in each year (Activity data)

Item			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
a. Anaerobic landfill	Mumicipal solid waste	Food waste	kt / year (dry)	358	278	172	99	86	74	61	52	43	37	31	26	23
		Paper/cardboard	kt / year (dry)	1042	913	724	545	514	486	451	423	393	367	343	319	297
		Textiles (natural fiber)	kt / year (dry)	54	48	38	31	31	29	28	25	23	21	19	18	16
		Wood	kt / year (dry)	186	186	179	167	165	162	160	157	154	152	149	147	144
		Human waste treatment, septic tank sludge	kt / year (dry)	96	66	44	29	28	25	22	19	17	15	13	12	10
		Ttsunami sediment	kt / year (dry)	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.2	0.4	0.9
	Industrial solid waste	Food waste	kt / year (dry)	86	127	146	89	76	65	55	48	41	36	31	28	23
		Paper/cardboard	kt / year (dry)	98	98	87	66	62	58	54	49	45	41	37	34	31
		Textiles (natural fiber)	kt / year (dry)	14	10	9	8	7	7	6	6	5	5	5	4	4
		Wood	kt / year (dry)	149	174	172	163	161	159	156	154	151	148	146	143	141
		Digested sewage sludge	kt / year (dry)	59	52	38	22	19	17	14	12	10	9	8	7	6
		Other sewage sludge	kt / year (dry)	221	196	144	83	72	62	53	46	39	34	30	26	22
		Waterworks sludge	kt / year (dry)	180	165	127	85	76	68	61	56	51	48	44	40	36
		Organic sludge from manufacturing industry	kt / year (dry)	341	262	153	87	76	66	58	50	43	38	34	30	33
		Livestock waste	kt / year (dry)	11	11	9	7	7	7	6	6	6	6	5	5	5
b. Semiaerobic landfill	Mumicipal solid waste	Food waste	kt / year (dry)	70	94	90	81	74	67	56	49	43	38	34	30	26
		Paper/cardboard	kt / year (dry)	119	191	232	262	264	267	257	254	248	243	237	231	222
		Textiles (natural fiber)	kt / year (dry)	6	10	12	18	20	19	19	18	16	15	14	13	12
		Woods	kt / year (dry)	10	16	21	25	25	26	26	26	26	26	26	26	26
		Human waste treatment, septic tank sludge	kt / year (dry)	14	18	20	22	23	22	19	18	16	15	14	13	12
	Industrial solid waste	Food waste	kt / year (dry)	5	19	45	46	42	39	35	33	31	28	28	29	26
		Paper/cardboard	kt / year (dry)	4	9	15	18	19	19	19	18	17	15	14	13	12
		Textiles (natural fiber)	kt / year (dry)	1	1	2	2	3	3	3	2	2	2	2	2	2
		Wood	kt / year (dry)	4	10	14	17	18	19	19	19	19	19	19	19	19
		Digested sewage sludge	kt / year (dry)	3	6	9	8	8	7	7	6	5	5	4	4	4
		Other sewage sludge	kt / year (dry)	13	23	33	32	30	28	25	22	20	18	19	18	17
		Waterworks sludge	kt / year (dry)	12	20	30	36	35	35	35	36	37	37	38	39	41
		Organic sludge from manufacturing industry	kt / year (dry)	21	28	28	31	30	28	27	24	22	21	22	22	37
		Livestock waste	kt / year (dry)	1	1	2	4	4	4	4	5	5	5	6	6	6

Note: The declining trend in the amount of biodegraded waste is affected by the improvement of waste reduction that causes the decrease of landfilled waste.

- ***Amount of CH_4 recovered from Landfills***

In order to reduce the amount of organic matter content and CH_4 emissions at landfill sites, certain intermediate treatments and landfill methods have been conducted; CH_4 recovery from landfills is not very common practice in Japan. CH_4 recovery from landfilled MSW for the purpose of electric power generation implemented at the Tokyo Metropolitan Inner Landfill Site for the Central Breakwater "Uchigawa-Shobunjo" is the sole practice example in Japan. For IW, there is no practice of CH_4 recovery from landfills implemented in Japan. Because CO_2 emitted from the combustion of recovered CH_4 is of biogenic-origin, it is not included in the total emissions.

$$R = r \times f \times 16/22.4/1000$$

Where:

R : Amount of CH_4 recovered in landfill [g]

r : Amount of recovered landfill gas used for electric power generation [m^3 N]

f : Ratio of CH_4 to recovered gas [-]

- ***The amount of recovered landfill Gas used for electric power generation in "Uchigawa-Shobunjo" Landfill***

The amount of recovered gas used for electric power generation is provided by the Waste Disposal Management Office of Tokyo.

- ***Fraction of CH_4 to the recovered gas***

The fraction of CH_4 to recovered landfill gas in the *Uchigawa-Shobunjo* has been annually provided since FY2005 by the Waste Disposal Management Office of Tokyo. The fraction for the years prior to FY2005 are determined based on the hearing conducted with the Waste Disposal Management Office of Tokyo: 60% for FY1987, when the recovery of landfill gas was started; 40% for FY1996; interpolated for FY1988 through FY1995; The FY1996 value is used for FY1997 through FY2004.

Table 7-14 Amount of CH_4 recovered at landfill sites in Japan

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Amount of gaseous use	km^3 N	1,985	2,375	2,372	140	1,309	1,157	1,161	1,154	1,266	1,032	1,681	1,734	1,612
CH_4 ratio	%	53.3	42.2	40.0	48.5	42.1	37.4	37.1	40.0	43.8	51.2	49.5	44.9	41.0
Amount of CH_4 use	km^3 N	1,059	1,003	949	68	551	433	431	462	555	528	832	779	661
CH_4 unit conversion	Gg-CH_4	0.76	0.72	0.68	0.05	0.39	0.31	0.31	0.33	0.40	0.38	0.59	0.56	0.47

Note: The consumption of gas used for electric power generation during 1991-1994 had decreased compared to the preceding year and the following year because recovered gas was used for the purposes other than electric power generation. The consumption of recovered gas used for electric power generation had decreased compared to 1996 because no electric power generation using recovered gas was conducted between late 1994 and early 1995 due to the relocation of electric power generation facilities. Amount of gas used in 2005 has dropped to less than 10 percent over the previous year because the electric power generating equipment had been halted from April, 2005 to Mid-February, 2006. After resumption, methane concentration was high through to the end of the fiscal year.

- ***CH_4 Oxidation Factor Related by Landfill Cover Soil***

Based on law enforcement ordinances and local government ordinances, daily, intermediate and final soil coverings are practiced in the managed final disposal sites for MSW and IW in Japan. Therefore, the default oxidation factor for managed landfill sites (0.1) is used in accordance with the *2006 IPCC Guidelines*.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties in emission factors for municipal solid waste and industrial waste on the category are assessed by combining the uncertainties in carbon content, fraction of degradable organic carbon dissimilated, percentages of CH_4 in landfill gas, methane correction factor (MCF), and oxidation factor evaluated by using the 95% confidence interval obtained from actual measurement, or by expert judgment.

Regarding the uncertainty for activity data for this sector, due to the lack of information on statistical error in quoted references, it is difficult to assess uncertainties based on concrete evidence. Therefore, it is assessed by expert judgment as indicated in the Table 7-2. Details of the uncertainty assessment on this category are shown in the Table 7-15.

Table 7-15 Uncertainty assessment by waste type on the category "managed disposal sites (5.A.1.)"

Item		GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
			(-)	(+)	(-)	(+)	(-)	(+)			
Municipal waste	Food waste	CH_4	-47%	+47%	-10%	+10%	-48%	+48%	The uncertainties in emission factors are evaluated by combining the 95% confidence interval of actual measurement data of carbon content, the uncertainty in fraction of degradable organic carbon dissimilated and proportion of methane in generated gas based on expert judgment, and the uncertainty in default value of MCF and oxidation factor provided by 2006GL, by using the formula for propagation of errors. (Method 1)	The uncertainty in municipal waste statistics based on expert judgment is applied.	Combined by using the formula for propagation of errors
	Paper/cardboard	CH_4	-47%	+47%	-10%	+10%	-48%	+48%			
	Textiles	CH_4	-47%	+47%	-10%	+10%	-48%	+48%			
	Wood	CH_4	-47%	+47%	-10%	+10%	-48%	+48%			
	Human waste treatment/ septic tank sludge	CH_4	-49%	+49%	-10%	+10%	-50%	+50%			
	Tsunami sediment	CH_4	-47%	+47%	-10%	+10%	-48%	+48%	The uncertainty in emission factor for wood is substituted, since the substance of tsunami sediment for estimation is assumed to be wood.		
Industrial waste	Food waste	CH_4	-47%	+47%	-30%	+30%	-56%	+56%	The uncertainty is evaluated by using method 1.	The uncertainty in industrial waste statistics based on expert judgment is applied.	Combined by using the formula for propagation of errors
	Paper/cardboard	CH_4	-47%	+47%	-30%	+30%	-56%	+56%			
	Textiles	CH_4	-47%	+47%	-30%	+30%	-56%	+56%			
	Wood	CH_4	-47%	+47%	-30%	+30%	-56%	+56%			
	Sewage sludge	CH_4	-49%	+49%	-5%	+5%	-49%	+49%	The uncertainty in emission factor is evaluated by using method 1.The uncertainty of carbon content in the method is evaluated based on expert judgment.	The uncertainty in the sewage statistics based on expert judgment is applied.	
	Waterworks sludge	CH_4	-51%	+51%	-5%	+10%	-51%	+52%	The uncertainty is evaluated by using method 1.	The uncertainty in the waterworks statistics based on expert judgment.is applied	
	Organic sludge from manufacturing industries	CH_4	-58%	+58%	-30%	+30%	-65%	+65%	The uncertainty in emission factor is evaluated by using method 1.The uncertainty of carbon content in the method is evaluated by expert judgment.	The uncertainty in industrial waste statistics based on expert judgment is applied.	
	Livestock waste	CH_4	-51%	+51%	-30%	+30%	-59%	+59%	The uncertainty in emission factors is evaluated by using method 1. For the carbon content in the method, the uncertainty provided by 2006GLs as default value is applied.		
Methane recovery		CH_4	-10%	+10%	-10%	+10%	-14%	+14%	The uncertainty of Methane concentration in recovered gas is evaluated based on expert judgment.	The uncertainty in municipal waste statistics based on expert judgment is applied.	Combined by using the formula for propagation of errors

- ***Time-series Consistency***

Although some activity data in FY1990 and thereafter are not available, they are estimated by using the methods described in "Activity data" to develop consistent time-series data. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Updating the statistical data including past landfill amount, emission estimates were recalculated. For detail, see the section "7.1.5. General Recalculations for Emissions from Waste Sector". See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

Further improvements are planned owing to a lack of sufficient current information. Major issues are:

- Fraction of degradable organic carbon dissimilated for each type of biodegradable waste;
- Country-specific half-life for sludge at final disposal sites;
- Considering the possibility of CO_2 emission from paper/cardboard containing fossil fuel-derived carbon.

7.2.2. Unmanaged Waste Disposal Sites (5.A.2.)

a) Category Description

Because landfill sites in Japan are appropriately managed pursuant to the Waste Disposal and Public Cleansing Law, there are no unmanaged waste disposal sites in Japan. Therefore, the emissions from this source category are reported as "NO".

7.2.3. Uncategorized Waste Disposal Sites (5.A.3.)

7.2.3.1. Inappropriate Disposal (5.A.3.-)

a) Category Description

In Japan, the definition of "inappropriate disposal" is waste disposal violating the Waste Disposal and Public Cleansing Law (illegal dumping and other forms of improper disposal on lands or areas other than landfill sites). The ratio of the amount of inappropriate waste disposal is quite small comparing to the one of appropriate waste disposal. Although these inappropriate disposal lands or areas generally satisfy the conditions of managed disposal sites defined in the *2006 IPCC Guidelines*, CH_4 emissions from inappropriate disposal are reported under "Uncategorized waste disposal sites (5.A.3.)".

Fires are occasionally observed in inappropriate landfill sites, and they may be emitting fossil-fuel derived CO_2. However, since actual data are not available, the emissions from the fires at inappropriate landfill sites are reported as "NE".

b) Methodological Issues

- ***Estimation Method***

Wood and paper/cardboard are the wastes containing biodegradable carbon and being inappropriately disposed without incineration; however, only wood is the subject for the estimation, because the residual amount of paper/cardboard should be very small.

In a similar manner for the "Managed Disposal Sites (5.A.1.)", a FOD method with Japan's country-specific parameters is used for the estimation. Emissions are estimated by multiplying the amount of wood (dry basis) degraded in a reporting year by an emission factor. Since the condition of CH_4 emissions from inappropriate disposal is unidentified, it is regarded as almost the same as for the anaerobic landfill.

- ***Emission Factor***

Adopting 1.0 of methane correction factor for anaerobic decomposition and 45.2% of fraction of carbon content in wood, the same emission factor as shown in Table7-7 is used for the anaerobic disposal sites for "wood emissions from managed disposal sites".

- ***Activity Data***

Activity data (dry basis) is obtained by subtracting the water content from the residual amount of inappropriately disposed wood (wet basis) and multiplied by methane generation rate constant. The amount of inappropriately disposed wood is provided by "Wood (Construction and Demolition)" in *Study on Residual Amounts of Industrial Waste from Illegal Dumping and other Sources* (Waste Management and Recycling Department, Ministry of the Environment). The percentage of water content and the methane generation rate constant used for estimating emissions from wood in managed disposal sites are also used for this source.

Table 7-16 Inappropriately disposed wood to be degraded in each estimation year (dry basis)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Activity data	kt (dry)	2.3	5.5	16.0	15.7	15.6	15.2	14.2	13.5	13.5	13.2	13.2	12.4	11.5

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties in emission factor and activity data are evaluated by using the same methods that are used for "Managed Disposal Sites (5.A.1.)". Details of the uncertainty assessment on this category are shown in the Table 7-17.

Table 7-17 Uncertainty assessment on the category "inappropriate disposal sites (5.A.3.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Inappropriately disposed waste	CH_4	-42%	+41%	-60%	+60%	-74%	+73%	The uncertainty in emission factor for wood is substituted, since the source for estimation is assumed to be wood.	The twofold higher uncertainty than the value in industrial waste statistics is applied based on expert judgment.	Combined by using the formula for propagation of errors

- ***Time Series Consistency***

Because data on inappropriate disposal are available only since FY2002, activity data prior to FY2002 are estimated. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Due to the removals of inappropriate disposal, revelations of past inappropriate disposal, and etc., the amount of identified inappropriate disposal in the past has been updated annually. Due to the changes in the amount of inappropriate disposal, emission estimates were recalculated. See chapter 10 for impact on trend.

f) Category-specific Planned Improvements

For future inventories, long-term efforts on further scientific investigations will be made to identify country-specific parameters.

7.3. Biological Treatment of Solid Waste (5.B.)

In this category, CH_4 and N_2O emissions from biological treatment of solid waste are calculated. The target categories are shown in Table 7-18.

Table 7-18 Categories whose emissions are estimated for biological treatment of solid waste (5.B.)

Category	Waste type		Treatment type	CH_4	N_2O
5.B.1. (7.3.1)	Municipal solid waste	Municipal solid waste (Food waste, Paper/cardboard, Wood, Textile)	Composting	○	○
		Human waste/septic tank sludge		○	○
	Industrial waste	Sewage sludge		○	○
		Food waste (Animal and vegetable residues, Other food waste)		○	○
5.B.3. (7.3.3)	Municipal solid waste		Anaerobic digestion	NO	NO

Estimated greenhouse gas emissions from this category are shown in Table 7-19. In FY2014, emissions from this source category are 609 kt-CO_2 eq. and accounted for 0.04% of the national total emissions (excluding LULUCF). The emissions from this source category had increased by 82.4% compared to those in FY1990. This emission increase is primarily due to the enhancement of effective utilization of waste as recycled resources.

Table 7-19 GHG emissions from biological treatment of solid waste (5.B.)

Gas	Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	5.B.1. Composting	Municipal solid waste	kt-CH_4	0.4	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.5	0.5	0.6
		Human waste/septic tank sludge	kt-CH_4	NO	NO	NO	0.01	0.02	0.03	0.1	0.2	0.1	0.05	0.1	0.1	0.1
		Sewage sludge	kt-CH_4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4
		Food waste	kt-CH_4	7.0	7.0	7.0	12.7	13.0	12.5	14.1	13.8	12.1	13.3	13.3	13.2	13.1
	5.B.2. Anaerobic digestion at biogas facilities		kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-CH_4	7.8	7.6	7.8	13.6	14.0	13.5	15.2	15.1	13.2	14.5	14.4	14.2	14.2
			kt-CO_2 eq.	195	191	194	340	350	337	380	377	329	362	359	355	355
N_2O	5.B.1. Composting	Municipal solid waste	kt-N_2O	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
		Human waste/septic tank sludge	kt-N_2O	NO	NO	NO	0.001	0.001	0.002	0.01	0.01	0.003	0.003	0.004	0.003	0.005
		Sewage sludge	kt-N_2O	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.03	0.03	0.03
		Food waste	kt-N_2O	0.42	0.42	0.42	0.76	0.78	0.75	0.85	0.83	0.73	0.80	0.80	0.79	0.79
	5.B.2. Anaerobic digestion at biogas facilities		kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		kt-N_2O	0.47	0.46	0.47	0.81	0.84	0.81	0.91	0.90	0.79	0.87	0.86	0.85	0.85
			kt-CO_2 eq.	139	137	139	243	250	241	271	269	236	259	257	254	254
Total			kt-CO_2 eq.	334	328	333	582	600	579	651	646	565	621	616	610	609

7.3.1. Composting (5.B.1)

a) Category Description

Part of the MSW and industrial waste generated in Japan is composted, and CH_4 and N_2O generated in that process are emitted from composting facilities. Emissions from composting of livestock waste are accounted for under "5.3. Manure management (3.B)" in the agriculture sector.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated by taking the amount of organic waste composted, which is obtained from the statistical information available in Japan, and multiplying it by the default emission factor provided in the *2006 IPCC Guidelines*. The calculation method is the same for both CH_4 and N_2O emissions.

$$E = EF \times A$$

E : Amount of CH_4 or N_2O emissions generated by composting organic waste [kg-CH_4], [kg-N_2O]

EF : Emission factor (dry basis) [kg-CH_4/t], [kg-N_2O/t]

A : Amount of composted organic waste (dry basis) [t]

- ***Emission Factor***

In accordance with the *2006 IPCC Guidelines*, emission factors (dry basis) are set as 10.0 [kg-CH_4/t] for $CH_4$and 0.6 [kg-N_2O/t] for N_2O, respectively, for all fiscal years.

- ***Activity Data***

Activity data (amount composted on a dry basis) is obtained by subtracting the water content appropriate to the properties of composted waste from the amount of composted waste (wet basis). Percentage of water content in composted waste, as indicated in the Table 7-10, are 20% in paper/cardboard, 75% in food waste, 20% in textiles, 45% in wood, and 70% in sewage sludge.

➢ ***Municipal Solid Waste***

- ***Municipal solid waste excl. human waste***

- Amount of composted waste by waste type is calculated by multiplying the amount of MSW treated at waste composting facilities indicated in the *Waste Treatment in Japan* by the fraction of

waste types in MSW treated at high-rate composting facilities provided in the *Cyclical Use of Waste Report.*

- ***Human waste/septic tank sludge***
  - Amount of human waste composted at waste composting facilities is indicated in the Ministry of the Environment, Waste Management and Recycling Department, *The state of municipal waste treatment survey*.

➢ ***Industrial Waste***

- ***Sewage sludge***
  - Amount of sewage sludge treated at composting facilities is provided by the *Sewage Statistics*.
  - Amount of additives (e.g. wood, etc.) to be mixed with sewage sludge treated at composting facilities is provided by the *Sewage Statistics.*

- ***Food waste***

Amount of composted animal and vegetable residues is indicated in the *Review Report on Improvement of Accuracy and Faster Compilation of Waste Statistics*; this category includes;

- Animal and vegetable residues generated by food and beverage manufacturing.
- Food waste including valuables other than the above: although under the Waste Disposal and Public Cleansing Law, they fall under the category of industrial waste, it is included in industrial waste because of its source and properties.
- Amount of additives (e.g. wood, etc.) to be mixed with food waste is estimated by using additive ratio of 30% in food waste, derived from expert judgment referring to the *Cyclical Use of Waste Report*.

Table 7-20 Amounts of composted waste

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Municipal solid waste	kt (dry)	38	22	29	35	39	43	45	51	56	58	52	54	56
Human waste/ septic tank sludge	kt (dry)	NO	NO	NO	1	2	3	8	17	5	5	6	6	8
Sewage sludge (incl. additive)	kt (dry)	39	42	46	48	56	58	55	61	45	52	45	42	43
Food waste (incl. additive)	kt (dry)	701	701	701	1,274	1,301	1,245	1,410	1,377	1,212	1,334	1,333	1,320	1,313

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

Since the emission factors are provided by the *2006 IPCC guidelines* as default value, the uncertainty in emission factors is evaluated according to the default uncertainties assessment in the guidelines. As for the uncertainty in activity data, since valuables account for much of activity data in biological treatment, the uncertainty for valuables indicated in Table 7-2 is adopted for activity data based on expert judgment. Details of the uncertainty assessment on this category are indicated in the Table 7-21.

Table 7-21 Uncertainty assessment on the category "composting (5.B.1.)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Composting	CH_4	-99%	+100%	-30%	+30%	-104%	+104%	The uncertainty is evaluated according to the default uncertainty assessment in 2006GLs because the emission factor for this item is the default value in 2006GLs.	The uncertainty in valuables based on expert judgment is applied since AD mostly consists of valuables.	Combined by using the formula for propagation of errors
	N_2O	-67%	+167%	-30%	+30%	-73%	+169%			

- ***Time-series Consistency***

Since the amount of composted animal and plant residues generated by food manufacturing and food waste other than those for FY1990-2000 are unavailable, the data for FY2001 are used for those years. Since the data of the amount of additives (e.g. wood, etc.) to be added to sewage sludge treated at composting facilities for FY1990-1995 are unavailable, those data are estimated by multiplying the sewage sludge for FY1990-1995 by the ratio of additives for FY1996; thus, time series consistency in emission estimates has been ensured.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Updating the statistical data, emission estimates were recalculated. For detail, see the section "7.1.5. General Recalculations for Emissions from Waste Sector". See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

For future inventories, detailing of emission estimates will be conducted upon new scientific findings because the necessity of establishing country-specific emission factor from this source has been well recognized.

The implementation of emission estimates from domestic and commercial composting machine will be further considered. Because this kind of research could not be completed in a short period of time, a long-term efforts on scientific investigations will be necessary.

7.3.2. Anaerobic Digestion at Biogas Facilities (5.B.2.)

a) Category Description

- ***Biogas facilities in Japan***

As biogas facilities to be considered in this category, anaerobic digestion equipment at sewage treatment plants, biogas facilities for municipal waste, and biogas facilities for industrial waste are operated in Japan.

- ***Anaerobic digestion equipment for sewage sludge at sewage treatment plants***

"*Guidelines and Explanation of Sewerage Facility Design, Japan Sewage Works Association*, 2009" states that, digestion tanks for sludge at sewage treatment plants should be kept air tight to prohibit explosions and odors caused by biogas leakage. It also states that unutilized digestion gas from these equipment should be combusted in views of safety and climate change mitigation. In addition, Japan estimates CH_4 and N_2O emissions from sludge thickening tank and dehydration room by using emission factors considering whole treatment system including these processes; CH_4 and N_2O emissions from this source stated in the *2006 IPCC Guidelines* are included in "5.D.1. domestic wastewater treatment".

- ***Biogas facilities for municipal waste***

"*Manual on biogas facilities maintenance, Ministry of Environment*, 2008" states that fermentation equipment at biogas facilities for municipal waste should be kept air tight. It also states that biogas from these equipment should be combusted by the excess gas combustion system and discharged safely when the facilities cannot supply biogas to consumers in emergencies or maintenances.

- ***Biogas facilities for industrial waste***

Although biogas facilities for industrial waste are not controlled by the guidelines such as for these for municipal waste, operators ought to keep air tight at the facilities in their installations as a safety measure.

- ***Emission estimates***

In accordance with above, the emissions from this source category are reported as "NO".

7.4. Incineration and Open Burning of Waste (5.C.)

In Japan, waste disposed of has been reduced in volume primarily by incineration. Emissions from waste incineration are categorized as shown in Table 7-22. CO_2, CH_4, N_2O emissions without energy recovery are allocated to this category.

Table 7-22 Categories whose emissions are estimated for waste incineration and open burning (5.C.)

Category	Waste type			Category to be allocated to CRF	Treatment type		CO_2	CH_4	N_2O
5.C.1 (7.4.1)	Municipal solid waste (7.4.1.1)	Plastics	Fossil-fuel derived plastics	Non-biogenic/MSW	Incineration without energy recovery	Incinerator -continuous -semi-continuous -batch type Gasification melting furnace	○	○[2]	○[2]
			Biomass-based plastics	Biogenic/MSW			NA[1]		
		Paper/ cardboard	Fossil-fuel derived fraction	Non-biogenic/MSW			○		
			Biogenic fraction	Biogenic/MSW			NA[1]		
		Nappy (Fossil-fuel derived fraction)		Non-biogenic/MSW			○		
		Textiles	Synthetic textile	Non-biogenic/MSW			○		
			Natural fiber	Biogenic/MSW			NA[1]		
		Other (biogenic)		Biogenic/MSW			NA[1]		
	Industrial waste (7.4.1.2)	Waste oil	Fossil-fuel derived oil	Non-biogenic/ Fossil liquid waste		Incinerator	○	○	○
			Animal and vegetable oil	Biogenic/ Non- fossil liquid waste			NA[1]	○	○
		Plastics	Fossil-fuel derived plastics	Non-biogenic/ISW			○	○	○
			Biomass-based plastics	Biogenic/ISW			NA[1]	IE[3]	IE[3]
		Food waste [Animal and vegetable residues/animal carcasses]		Biogenic/ISW				○	○
		Paper/ cardboard	Fossil-fuel derived fraction	Non-biogenic/ISW			○	IE[4]	IE[4]
			Biogenic fraction	Biogenic/ISW			NA[1]	○	○
		Wood		Biogenic/ISW				○	○
		Textile	Synthetic textile	-			IE[3]	IE[3]	IE[3]
			Natural fiber	Biogenic/ISW			NA[1]	○	○
		Sludge	Sewage sludge	Biogenic/Sludge		Various types of incinerations[5]	NA[1]	○	○
			Other than sewage sludge	Biogenic/Sludge		Incinerator	NA[1]	○	○
	Specially controlled industrial waste (7.4.1.3)	Waste oil	Flammable waste oil	Non-biogenic/ Hazardous waste			○	○	○
			Specified hazardous waste oil	Non-biogenic/ Hazardous waste			○	○	○
		Infectious waste	Plastics (Fossil-fuel derived)	Non-biogenic/ Clinical waste			○	○	○
			Other (except plastics)	Biogenic/ Clinical waste			NA[1]	○	○
5.C.2 (7.4.2)				-	Open burning		NO	NO	NO

Note:

1) CO_2 emissions from the incineration of biomass-derived waste are not included in the total emissions in accordance with the *2006 IPCC Guidelines*; instead it is estimated as a reference value and reported under "Biogenic" in Table 5.C of the CRF.
2) CH_4 and N_2O emissions from incineration of municipal solid waste in bulk are estimated by each incineration type and reported under "Non-biogenic/MSW" in Table 5.C of the CRF.
3) Included in fossil-fuel derived plastics in industrial solid waste (ISW)
4) Included in biogenic fraction of paper/cardboard
5) For details of incineration types for sewage sludge, see section 7.4.1.2.

Also, waste incineration includes the following practices of waste used as raw material or fuel:

- Waste Incineration with Energy Recovery (1.A.) (See section 7.4.3.1.)
- Direct Use of Waste as Alternative Fuel (1.A.) (See section 7.4.3.2.)
- Incineration of Waste Processed as Fuel (1.A.) (See section 7.4.3.3.)

In accordance with the *2006 IPCC Guidelines*, estimated emissions from the sources listed above are allocated to Energy sector (Category 1) as "7.4.3. Waste Incineration and Energy Use (Reported on Energy Sector) (1.A.)" . For details of reporting category on energy sector, see Table 7-24.

In order to avoid double-counting or any other confusion, emissions from the categories indicated in Table 7-22, Table 7-23 and Table 7-24 with or without energy use are estimated collectively under the waste sector, thus the estimation methodology for these categories are provided in this section.

Table 7-23 Waste types whose emissions are estimated for "Waste Incineration and Energy Use (Reported on Energy Sector) (1.A.)"

Category	Waste type			Fuel type on energy sector to be allocated to CRF	Treatment type		CO_2	CH_4	N_2O
1.A.1. (7.4.3.1)[7]	Municipal solid waste	Plastics	Fossil-fuel derived plastics	Other fossil fuels	Incineration with energy recovery	・Incinerator -continuous, -semi-continuous -batch type ・Gasification melting furnace	○	○[2]	○[2]
			Biomass-based plastics	Biomass			NA[1]		
		Paper/ cardboard	Fossil-fuel derived fraction	Other fossil fuels			○		
			Biogenic fraction	Biomass			NA[1]		
		Nappy (Fossil-fuel derived fraction)		Other fossil fuels			○		
		Textiles	Synthetic textile	Other fossil fuels			○		
			Natural fiber	Biomass			NA[1]		
		Other (biogenic)		Biomass			NA[1]		
	Industrial waste	Waste oil	Fossil-fuel derived oil	Other fossil fuels		Incinerator	○	○	○
			Animal and vegetable oil	Biomass			NA[1]	○	○
		Plastics	Fossil-fuel derived plastics	Other fossil fuels			○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
		Food waste [Animal and vegetable residues/animal carcasses]		Biomass			NA[1]	○	○
		Paper/ cardboard	Fossil-fuel derived fraction	Other fossil fuels			○	IE[4]	IE[4]
			Biogenic fraction	Biomass			NA[1]	○	○
		Wood		Biomass			NA[1]	○	○
		Textile	Synthetic textile	-			IE[5]	IE[5]	IE[5]
			Natural fiber	Biomass			NA[1]	○	○
		Sludge	Sewage sludge	-			NO	NO	NO
			Other than sewage sludge	Biomass			NA[1]	○	○
	Specially controlled industrial waste			-			IE[5]	IE[5]	IE[5]
1.A.1/2 (7.4.3.2)[7]	Municipal solid waste	Plastics	Fossil-fuel derived plastics	Other fossil fuels		Direct use as alternative fuel	○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
	Industrial waste	Waste oil	Fossil-fuel derived oil	Other fossil fuels			○	○	○
			Animal and vegetable oil	Biomass			NA[1]	○	○
		Plastics	Fossil-fuel derived plastics	Other fossil fuels			○	○	○
			Biomass-based plastics	Biomass			NA[1]	IE[3]	IE[3]
		Wood		Biomass			NA[1]	○	○
	Waste tire		Fossil-fuel derived fraction	Other fossil fuels			○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]
1.A.1/2 (7.4.3.3)[7]	Refuse Derived Fuel (RDF)		Fossil-fuel derived fraction	Other fossil fuels		Incineration of waste processed as fuel	○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]
	Refuse Paper and Plastic Fuel (RPF)		Fossil-fuel derived fraction	Other fossil fuels			○	○	○
			Biogenic fraction	Biomass			NA[1]	IE[6]	IE[6]

Note:

1) CO_2 emissions from the incineration of biomass-derived waste are not included in the total emissions; instead it is estimated as a reference value and reported as "Biomass" fuel in the CRF tables.
2) CH_4 and N_2O emissions from incineration of municipal solid waste in bulk are estimated by each incineration type and reported as "Other fossil fuels" in the CRF tables.
3) Included in fossil-fuel derived plastics in ISW
4) Included in biogenic fraction of paper/cardboard
5) Included in "Specially-controlled industrial waste" incineration without energy recovery
6) Included in the fossil-fuel derived fraction
7) For details of categories to be reported in the CRF, see Table 7-24.

Table 7-24 Reporting categories on the energy sector whose emissions are estimated for waste incineration and energy use

Treatment type	Waste type		Application breakdown	Major application	Reporting category on the energy sector	CO_2 [3]	CH_4	N_2O
Waste incineration with energy recovery	MSW		-	Waste incineration with energy recovery	1.A.1.a. Public electricity and heat production	○	○	○
	Industrial waste					○	○	○
Direct use of waste as alternative fuel	MSW Plastics		Petrochemical	Fuel	1.A.2.g. Other	○	○	○
			Blast furnace reducing agent	Reducing agent in blast furnace	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Coke oven chemical feedstock	Alternative fuel or raw material in coke oven	1.A.1.c. Manufacture of solid fuels and other energy industries	○	IE[5]	NO[6]
			Gasification	Fuel	1.A.2.g. Other	○	NE[7]	NE[7]
	Industrial waste	Waste oil	Other	Fuel	1.A.2.g. Other	○	○	○
		Plastics	Blast furnace reducing agent	Blast furnace reducing agent	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Boiler	Fuel	1.A.2.c. Chemicals	○	○	○
			Boiler	Fuel	1.A.2.d. Pulp, paper and print	○	○	○
			Cement burning	Cement burning	1.A.2.g. Other	○	○	○
			Boiler	Fuel	1.A.2.g. Other	○	○	○
		Wood	-	Fuel	1.A.2.g. Other	NA	○	○
	Waste tire		Cement burning	Cement burning	1.A.2.g. Other	○	○	○
			Boiler	Fuel	1.A.2.g. Other	○	○	○
			Iron manufacture	Alternative fuel or raw materials in iron manufacturing	1.A.2.a. Iron & Steel	○	NO[4]	NO[4]
			Gasification	Fuel in iron manufacturing	1.A.2.a. Iron & Steel	○	○	○
			Metal refining	Fuel in metal refining	1.A.2.b. Non-ferrous metals	○	○	○
			Tire manufacture	Fuel in tire manufacturing	1.A.2.c. Chemicals	○	○	○
			Paper manufacture	Fuel in paper manufacturing	1.A.2.d. Pulp, paper and print	○	○	○
			Power generation	Power generation	1.A.1.a. Public electricity and heat production[1]	○	○	○
Incineration of waste processed as fuel	Refuse-derived fuel (RDF)		-	Fuel use (including power generation)	1.A.2.g. Other[2]	○	○	○
	Refuse-derived fuel (RPF)		Petroleum product manufacturer	boiler fuel	1.A.1.b. Petroleum refining	○	○	○
			Chemical industry	boiler fuel	1.A.2.c. Chemicals	○	○	○
			Paper industry	Fuel use in paper manufacturing	1.A.2.d. Pulp, paper and print	○	○	○
			Cement manufacturer	Cement burning	1.A.2.g. Other	○	○	○

Note:

1) Since the industry category for the use of it is not identified, "1.A.1.a." is applied.
2) Emissions from power generation and heat supply excluding in-house use should be included in the category 1.A.1.a. However, they are reported in the category 1.A.2.g., because the actual circumstances are not understood at the moment.
3) CO_2 emissions from the incineration of biomass-derived fraction are not included in the total emissions; instead it is estimated as a reference value and reported as "Biomass" fuel in the CRF tables. For detail, see Table 7-23 .
4) Blast furnace gas generated from steel industry is entirely recovered.
5) These emissions are included in "solid fuels" in same category 1.A.1.c.
6) N_2O is likely not produced since the atmosphere in coke oven is normally at least 1,000 degree Celsius, and reducing.
7) Considering that small fraction of these sources is combusted as alternative fuel but these are mostly used to obtain feedstock for ammonia productions, the emissions are not estimated.

Estimated greenhouse gas emissions from waste incineration (category 5.C.) are shown in Table 7-25. In FY2014, emissions from waste incineration are 13,792 kt-CO_2 eq. and accounted for 1.0% of the national total emissions (excluding LULUCF). The emissions from this source category decreased by 0.6% compared to those in FY1990. For the period FY1990-FY1997, CO_2 emissions increased as the practice of intermediate treatment by waste incineration increased in order to decrease the total volume of waste landfilled. From FY2001 onwards, as the use of waste as raw material or fuel has been replacing the incineration of fossil-origin waste for intermediate treatments, and these CO_2

emissions which used to be allocated to the waste sector is now allocated to the Energy sector, CO_2 emission estimates from the waste sector decreased.

On the other hand, N_2O emissions increased compared to FY1990 level due to the increase in sewage sludge incineration practice for the period FY1990 - FY1997. From FY2005 onward, N_2O emissions from this source decreased because the practice of high temperature incineration of sewage sludge increased.

Table 7-25 GHG emissions from waste incineration (5.C.)

Gas	Category			Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	5.C.1. Waste incineration	Munisipal solid waste	Plastics[1)]	kt-CO_2	5,092	5,082	5,275	3,084	2,549	2,437	2,568	2,398	2,110	2,428	2,601	2,717	2,559
			Paper/cardboard[1)]	kt-CO_2	71	74	71	60	58	58	53	52	53	58	55	56	56
			Nappy[1)]	kt-CO_2	32	38	34	39	41	43	43	46	49	52	52	58	62
			Synthetic textiles[1)]	kt-CO_2	508	545	425	433	523	451	554	665	593	547	446	449	455
		Industrial waste	Waste oil[1)]	kt-CO_2	3,670	4,366	4,799	4,270	4,104	4,139	3,683	3,171	4,213	4,048	4,439	3,723	3,856
			Plastics[1)]	kt-CO_2	2,131	4,539	4,380	4,332	4,156	4,099	4,909	3,455	3,943	3,497	3,776	4,114	4,092
			Paper/cardboard[1)]	kt-CO_2	3	7	7	3	3	1	4	3	3	2	3	1	1
		Specially-controlled industrial waste	Waste oil (flammable)[1)]	kt-CO_2	698	1,036	1,526	1,402	1,352	1,364	2,547	1,845	1,143	815	784	814	825
			Waste oil (specific hazardous)[1)]	kt-CO_2	19	28	41	38	37	37	36	39	42	44	25	48	91
			Infectious waste (plastics)[1)]	kt-CO_2	199	328	428	435	420	462	336	366	395	452	336	341	349
	5.C.2. Open burning			kt-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total			kt-CO_2	12,424	16,041	16,986	14,096	13,242	13,092	14,733	12,039	12,543	11,943	12,518	12,322	12,346
CH_4	5.C.1. Waste incineration	Munisipal solid waste[2)]		kt-CH_4	0.5	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		Industrial waste	Waste oil[2)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Plastics[2)]	kt-CH_4	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Food waste[3)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Paper/cardboard[2)]	kt-CH_4	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0
			Wood[3)]	kt-CH_4	0.1	0.1	0.1	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.3
			Natural fiber[3)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Sludge (sewage sludge/ other)[3)]	kt-CH_4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Specially-controlled industrial waste	Waste oil (flammable)[1)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Waste oil (specific hazardous)[1)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Infectious waste (plastics)[1)]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Infectious waste (except plastics)[3)]	kt-CH_4	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	5.C.2. Open burning			kt-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total			kt-CH_4	0.6	0.7	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4
				kt-CO_2 eq.	16	18	16	17	16	14	14	12	12	11	12	12	11
N_2O	5.C.1. Waste incineration	Munisipal solid waste[2)]		kt-N_2O	1.03	1.05	0.98	0.52	0.52	0.51	0.47	0.48	0.46	0.49	0.46	0.47	0.45
		Industrial waste	Waste oil[2)]	kt-N_2O	0.02	0.02	0.02	0.10	0.09	0.10	0.09	0.07	0.10	0.09	0.10	0.09	0.09
			Plastics[2)]	kt-N_2O	0.15	0.32	0.31	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02
			Food waste[3)]	kt-N_2O	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
			Paper/cardboard[2)]	kt-N_2O	0.01	0.01	0.01	0.02	0.02	0.01	0.04	0.02	0.02	0.02	0.03	0.01	0.01
			Wood[3)]	kt-N_2O	0.06	0.10	0.06	0.14	0.13	0.12	0.10	0.09	0.08	0.08	0.09	0.10	0.09
			Natural fiber[3)]	kt-N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Sewage sludge[3)]	kt-N_2O	2.65	3.94	4.86	5.48	5.11	4.63	4.46	4.30	4.16	4.17	4.22	4.25	3.92
			Other sludge[3)]	kt-N_2O	0.89	0.92	0.94	0.22	0.22	0.22	0.20	0.21	0.20	0.20	0.17	0.19	0.19
		Specially-controlled industrial waste	Waste oil (flammable)[1)]	kt-N_2O	0.00	0.00	0.01	0.03	0.03	0.03	0.05	0.04	0.02	0.02	0.02	0.02	0.02
			Waste oil (specific hazardous)[1)]	kt-N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
			Infectious waste (plastics)[1)]	kt-N_2O	0.01	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			Infectious waste (except plastics)[3)]	kt-N_2O	0.00	0.00	0.00	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	5.C.2. Open burning			kt-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total			kt-N_2O	4.82	6.39	7.23	6.59	6.19	5.68	5.47	5.27	5.09	5.12	5.13	5.17	4.82
				kt-CO_2 eq.	1,435	1,905	2,155	1,963	1,843	1,694	1,629	1,571	1,517	1,524	1,528	1,542	1,436
Total				kt-CO_2 eq.	13,876	17,963	19,157	16,076	15,101	14,800	16,376	13,622	14,072	13,479	14,058	13,876	13,792

1) Include fossil-fuel derived component only
2) Include both fossil-fuel derived component and biogenic
3) Include biogenic component only

Note: CO_2 emissions from the incineration of biomass-derived waste (including biomass-based plastics and waste animal and vegetable oil) is not included in the total emissions in accordance with the *2006 IPCC Guidelines*; instead it is estimated as a reference value and reported under " Biogenic" in Table 5.C of the CRF.

For reference, the greenhouse gas emissions from waste incineration for energy purpose and with energy recovery are shown in Table 7-26. In FY2014, the emissions from waste incineration including

these sources are 30,093 kt-CO_2, and it accounts for 2.2% of Japan's total greenhouse gas emissions (excluding LULUCF). The emissions from this sources category had increased by 19.6% compared to those in FY1990.

Table 7-26 Total GHG emissions from incineration of waste (reference value) including emissions from waste incineration for energy use and energy recovery

Gas	Category				Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	5.C. Waste Incineration and open burning (without energy recovery)[1]				kt-CO_2	12,424	16,041	16,986	14,096	13,242	13,092	14,733	12,039	12,543	11,943	12,518	12,322	12,346
	1.A. Fuel combustion	Waste Incineration with Energy Recovery	MSW	Plastics[1]	kt-CO_2	5,916	6,373	8,270	6,663	5,382	5,045	5,555	4,685	4,267	4,545	5,458	5,380	5,067
				Paper/cardboard[1]	kt-CO_2	83	93	112	129	122	120	114	102	107	108	116	111	110
				Nappy[1]	kt-CO_2	38	48	53	83	87	90	92	90	99	98	109	114	122
				Synthetic textiles[1]	kt-CO_2	591	683	667	935	1,105	934	1,198	1,299	1,200	1,025	935	889	901
			IW	Waste oil[1]	kt-CO_2	21	30	28	109	104	98	79	68	91	87	96	80	83
				Plastics[1]	kt-CO_2	31	66	188	307	322	827	526	370	422	375	404	441	438
				Paper/cardboard[1]	kt-CO_2	0.0	0.1	0.1	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.0
		Direct Use of Waste as Alternative Fuel	MSW	Plastics[1]	kt-CO_2	NO	NO	92	511	472	442	370	413	455	435	465	233	229
			IW	Waste oil[1]	kt-CO_2	3,563	4,160	4,112	5,172	5,029	5,405	4,701	4,442	4,673	4,670	4,748	4,528	4,406
				Plastics[1]	kt-CO_2	55	59	448	1,209	1,236	1,375	1,352	1,469	1,534	1,539	1,613	1,585	1,949
			Waste Tire[1]		kt-CO_2	527	845	1,044	869	949	998	1,028	951	1,008	976	951	958	1,014
		Incineration of Waste Processed as Fuel	RDF[1]		kt-CO_2	26	30	114	319	304	305	297	289	292	299	295	295	297
			RPF[1]		kt-CO_2	NO	11	46	684	925	1077	1073	1113	1093	1147	1194	1263	1235
	Total				kt-CO_2	23,273	28,439	32,161	31,086	29,279	29,808	31,119	27,331	27,785	27,245	28,903	28,199	28,197
CH_4	5.C. Waste Incineration and open burning (without energy recovery)[2]				kt-CH_4	0.6	0.7	0.6	0.7	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.4
	1.A. Fuel combustion	Waste Incineration with Energy Recovery	MSW[2]		kt-CH_4	0.5	0.5	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
			IW	Waste oil[2]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Plastics[2]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Food waste[3]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Paper/cardboard[2]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Wood[3]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Natural Fiber[3]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Sludge other than sewage sudger[3]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Direct Use of Waste as Alternative Fuel	MSW	Plastics[2]	kt-CH_4	NO	NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NO	NO	NO	NO
			IW	Waste oil[2]	kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Plastics[2]	kt-CH_4	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
				Wood[3]	kt-CH_4	1.8	1.8	2.2	2.9	3.1	3.3	4.0	4.2	4.2	4.4	4.5	4.8	4.9
			Waste Tire[2]		kt-CH_4	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
		Incineration of Waste Processed as Fuel	RDF[2]		kt-CH_4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			RPF[2]		kt-CH_4	NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total				kt-CH_4	3.0	3.1	3.6	3.9	4.1	4.3	5.0	5.1	5.0	5.2	5.3	5.6	5.8
					kt-CO_2 eq.	75	78	90	98	102	106	124	128	126	130	133	141	144
N_2O	5.C. Waste Incineration and open burning (without energy recovery)[2]				kt-N_2O	4.82	6.39	7.23	6.59	6.19	5.68	5.47	5.27	5.09	5.12	5.13	5.17	4.82
	1.A. Fuel combustion	Waste Incineration with Energy Recovery	MSW[2]		kt-N_2O	1.19	1.32	1.53	1.13	1.11	1.06	1.02	0.95	0.93	0.91	0.97	0.93	0.90
			IW	Waste oil[2]	kt-N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Plastics[2]	kt-N_2O	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Food waste[3]	kt-N_2O	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
				Paper/cardboard[2]	kt-N_2O	0.01	0.01	0.01	0.02	0.02	0.01	0.04	0.02	0.02	0.02	0.03	0.01	0.01
				Wood[3]	kt-N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Natural Fiber[3]	kt-N_2O	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				Sludge other than sewage sudger[3]	kt-N_2O	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Direct Use of Waste as Alternative Fuel	MSW	Plastics[2]	kt-N_2O	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NO	NO	NO	NO
			IW	Waste oil[2]	kt-N_2O	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
				Plastics[2]	kt-N_2O	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
				Wood[3]	kt-N_2O	0.02	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06
			Waste Tire[2]		kt-N_2O	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Incineration of Waste Processed as Fuel	RDF[2]		kt-N_2O	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
			RPF[2]		kt-N_2O	NO	0.00	0.00	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	Total				kt-N_2O	6.06	7.78	8.86	7.86	7.44	6.88	6.67	6.38	6.18	6.19	6.27	6.26	5.88
					kt-CO_2 eq.	1807	2319	2641	2342	2218	2051	1987	1901	1842	1844	1867	1867	1752
Total					kt-CO_2 eq.	25,154	30,835	34,893	33,526	31,598	31,966	33,230	29,360	29,753	29,219	30,903	30,207	30,093

1) Include fossil-fuel derived component only
2) Include both fossil-fuel derived component and biogenic
3) Include biogenic component only

7.4.1. Waste Incineration (without Energy Recovery) (5.C.1.)

7.4.1.1. Municipal Solid Waste (5.C.1.-)

a) Category Description

This category covers the emissions from incineration of municipal solid waste without energy recovery. Emissions of CO_2 are reported under either "Biogenic, Municipal solid waste (MSW)" or "Non-biogenic, Municipal solid waste" in accordance with the waste type as indicated in the Table 7-22. Emissions of CH_4 and N_2O are estimated for each type of furnace. The data used for MSW incineration cannot distinguish wastes that are either biogenic-origin or non-biogenic origin. Therefore, total emissions including biogenic-origin ones are reported altogether under "Non-biogenic, Municipal solid waste".

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions of CO_2 from this emission source is calculated based on Japan's country-specific emission factors, the volume of waste incinerated (dry basis) and the percentage of municipal waste incinerated at the municipal incineration facilities that is accompanied by energy recovery, in accordance with the decision tree in the *2006 IPCC Guidelines* (Volume 5, Page 5.9, Fig. 5.1). In order to estimate CO_2 emissions from the incineration of fossil-fuel derived waste[2], emissions from fossil-fuel derived plastics, synthetic textile and fossil-fuel derived fraction in paper/cardboard and nappy in municipal solid waste are estimated.

$$E = \sum_i EF_i \times A_i \times (1 - R)$$

E : CO_2 Emissions from the incineration of municipal solid waste type i [kg-CO_2]
EF_i : Emission factor for the incineration of waste type i (dry basis) [kg-CO_2/t]
A_i : Volume of waste type i incinerated (dry basis) [t]
R : Percentage of municipal solid waste incinerated at facilities with energy recovery

- ***Emission Factor***

➢ ***Equation***

In accordance with the *2006 IPCC Guidelines*, the emission factor is calculated as follows.

- ***Fossil-fuel derived plastics, synthetic textile***

$$EF_i = CF_i \times OF \times 44/12$$

EF_i : Emission factor for the incineration of waste type i (dry basis) [kg-CO_2/t]
CF_i : Carbon content in waste type i (dry basis) [%]
OF : Oxidation factor [%]

[2] CO_2 emissions from the incineration of food waste, biogenic fraction of paper/cardboard, natural fiber textiles, wood and biomass-based plastics are accounted for as the reference figures of biogenic municipal waste. Estimation methods for their emissions are the same as those for emissions from the incineration of fossil-fuel derived waste.

- ***Paper/cardboard and nappy***

$$EF_i = CF_i \times FCF_i \times OF \times 44/12$$

EF_i : Emission factor for the incineration of waste type *i* (dry basis) [kg-CO_2/t]
CF_i : Carbon content in waste type *i* (dry basis) [%]
FCF_i : Fossil-fuel derived fraction in carbon in waste type *i* [%]
OF : Oxidation factor [%]

➢ ***Carbon Content***

The carbon content of plastics (fossil-fuel derived and biomass-derived waste) in MSW is estimated based on the averaged value of actual measured data for the period FY1990 - FY2008 provided by four municipalities (Akita city, Kawasaki city, Kobe city and Osaka pref.) and applying it for the entire time-series (Reference #18).

For the carbon content of synthetic textile in MSW, the carbon content of the synthetic fibers in the textile products is used. It is set by taking a weighted average of carbon contents determined by the molecular formula of polymer for each type of synthetic textile based on the volume of synthetic textile consumption.

For the carbon content of paper/cardboard in MSW, the carbon content of default value in the *2006 IPCC guidelines*, which is larger than country specific measured data (see Table 7-5) is conservatively applied.

For the carbon content of nappy in MSW, the carbon content of default value in the *2006 IPCC Guidelines* is used due to lack of domestic research in Japan.

Table 7-27 Carbon content of plastics and synthetic textile in MSW (dry basis)

Item	Carbon content	Source
Plastics	75.1 %	Averaged value of the data provided by four municipalities
Plastic bottles	62.5%	(Reference value) Estimated from the molecular formula of polyethylene terephthalate * Not adopted to estimate CO_2 emissions
Synthetic textile	63.0 %	Weighted average of carbon content by each type of synthetic textile
Paper/ cardboard	46.0 %	*2006 IPCC Guidelines*
Nappy	70.0 %	*2006 IPCC Guidelines*

➢ ***Fossil-fuel derived fraction in carbon in waste***

For the fossil-fuel derived fraction in carbon in paper/cardboard and nappy in MSW, the default values in the *2006 IPCC Guidelines* are applied as indicated in the Table 7-28 due to lack of domestic research in Japan.

Table 7-28 Fossil-fuel derived fraction in carbon in paper/cardboard and nappy in MSW

Item	Fossil-fuel derived fraction in carbon [%]	Source
Paper/ cardboard	1	*2006 IPCC Guidelines*
Nappy	10	*2006 IPCC Guidelines*

➢ ***Oxidation Factor***

Taking into account Japan's circumstances, the default value of 100% indicated in the *2006 IPCC Guidelines* is used.

➢ ***Emission Factor***

Emission factors calculated by methodologies above are shown in Table 7-29.

Table 7-29 Emission factors for plastics and synthetic textile in MSW (dry basis)

Item	Unit	Emission factor
Plastics	kg-CO_2/t	2,754
Synthetic textile	kg-CO_2/t	2,310
Paper/cardboard (Fossil-fuel derived)	kg-CO_2/t	17
Nappy (Fossil-fuel derived)	kg-CO_2/t	257

Table 7-30(Reference value) Emission factor for plastic bottles (dry basis)

Item	Unit	Emission factor	Remarks
Plastic bottles	kg-CO_2/t	2,292	Not adopted to estimate CO_2 emissions

● ***Activity Data***

As basic information to estimate activity data, the amount of plastic, plastic bottles distinguished from plastics, textiles and paper/cardboard incinerated are obtained from the *Cyclical Use of Wastes Report*. Note the reported amounts of plastic including plastic bottles potentially include biomass-based plastics. The details of activity data estimations are shown as follows.

➢ ***Fossil-fuel derived plastics***

The activity data for CO_2 emissions from the incineration of fossil-fuel derived plastics in MSW on a dry basis are calculated by subtracting water content from the amount of plastic incinerated (wet basis) and multiplying the fossil-fuel derived fraction of plastic incinerated in MSW.

Activity data for fossil-fuel derived plastics (MSW) incinerated (dry basis)
= Volume of plastics incinerated (wet basis) × (1 - Percentage of water content in plastics)
× Fossil-fuel derived fraction of plastics

In this method for MSW plastics, activity data is estimated separately as plastic bottles and the rest of plastics.

Activity data for fossil-fuel derived plastics (MSW) incinerated
= Activity data for fossil-fuel derived plastic bottles (MSW) incinerated
+ Activity data for fossil-fuel derived plastics (MSW) other than plastic bottles incinerated

- ***Percentage of water content in plastics***

The percentage of water content in plastic bottles/ plastics other than plastic bottles in MSW is defined as 20% provided by *Cyclical Use of Wastes Report.*

- ***Fossil-fuel derived fraction in plastic bottles/ plastics other than plastic bottles***

Fossil-fuel derived fraction in plastics is estimated as follows. For MSW, the parameters in this method are distinguished for plastic bottles and plastics other than plastic bottles, separately.

$$FPF(T) = 1 - \frac{BPW(T)}{PW(T)}$$

FPF(T) : Fossil-fuel derived fraction in MSW plastic in *FY T* [%]
BPW(T) : Amount of biogenic fraction in MSW plastic in *FY T* [t]

PW(T) : Amount of MSW plastic generation in *FY T* [t]

MSW plastics (plastic bottles / plastics other than plastic bottles) generation in *FY T* (*BPA(T)*) are obtained from the *Cyclical Use of Wastes Report*. Amount of biogenic fraction in MSW plastics (plastic bottles / plastics other than plastic bottles) in *FY T* (*BPW (T)*) are calculated by following equation.

$$BPW(T) = \sum_t^T \sum_i (BP_{i,t} \times DP_{i,t} \times B_i \times W_{i,t}(T) \times DW(T))$$

$BP_{i,ti}$: Amount of biomass-based plastic product *i* production in *FY t* [t]
$DP_{i,t}$: Share of domestic shipments of biomass-based plastic product *i* in *FY t* [%]
B_i : Biogenic fraction of biomass-based plastic product *i* [%]
$W_{i,t}(T)$: Probability that biomass-based plastic product *i*, which was produced in *FY t*, is disposed of as MSW in *FY T* after use [%]
DW(T) : Fraction of MSW plastic treated domestically in FY *T* [%]

For the amount of biomass-based plastic products production ($BP_{i,t}$), the share of domestic shipments ($DP_{i,t}$), and the biogenic fraction (B_i) are obtained from the *National Inventory Survey*, the Japan Society of Biomass Industries. Note that the survey distinguishes biomass-based plastic products by type (e.g. bio-PE, bio-PET, PLA, etc.) and use (e.g. plastic bottles, food containers, cushioning material, LCD, etc.). The probability that is disposed of as MSW ($W_{i,t}(T)$) is estimated by the expert judgement.

Table 7-31Total amount of biomass-based plastic production (dry basis) (Reference)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total amount of biomass-based plastics production	kt / year (dry)	NO	NO	NO	38	44	49	55	60	66	65	70	99	114

Source: *National Inventory Survey*, the Japan Society of Biomass Industries

Fractions of MSW plastics other than plastic bottles treated domestically in *FY T* (*DW(T)*) are assumed as 100% for plastics other than plastic bottles since the export status are not clear. The parameters for plastic bottles are obtained from *Annual report on PET bottle recycling*, the council for PET bottle recycling (Table 7-32).

Table 7-32 Fraction of waste plastic treated domestically

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Plastic bottle in MSW	%	48.6	48.6	48.6	48.6	48.6	48.6	48.6	47.4	47.5	50.5	50.9	51.6	57.1
Plastics other than Plastic bottles in MSW	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Plastics in IW	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Fossil-fuel derived fraction in plastic calculated by methodologies above are shown in Table 7-33.

Table 7-33 Fossil-fuel derived fraction in waste plastics (*FPF*)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Plastic bottle in MSW	%	100.0	100.0	100.0	99.8	99.7	99.7	99.7	99.6	99.5	99.5	99.5	99.2	99.0
Plastics other than Plastic bottles in MSW	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6	99.5
Plastics in IW	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8	99.8	99.8	99.8

➢ ***Synthetic textile***

The activity data of synthetic textile in MSW is estimated by multiplying the amount of textiles in MSW incinerated (wet basis) by the fraction of waste synthetic textile content in waste textile, and subtracting the water content in textiles (percentage of water content: 20%; see also Table 7-10).

Activity data for incineration of synthetic textile (MSW) (dry basis)
= Volume of textile incinerated (wet basis)
× (1 - Percentage of water content in textiles)
× Percentage of synthetic fiber content in textiles

- ***Percentage of Synthetic Textile in Textiles***

Percentage of synthetic textile content in textiles contained in the MSW is calculated using the percentage of synthetic textile products in textile products, which is determined by taking the ratio of the annual domestic demand for synthetic textile to the one for all textiles indicated in the Textile Handbook and the Yearbook of Textiles and Consumer Goods Statistics.

Table 7-34 Percentage of synthetic textile in textiles

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fraction of Synthetic textile	%	49.1	50.7	53.5	52.8	53.7	55.3	55.9	56.6	59.6	63.2	64.1	61.9	63.1

➢ ***Paper/cardboard***

The activity data of paper/cardboard in MSW is estimated by subtracting the water content (percentage of water content: 20%; see also Table 7-10) in paper/cardboard from the amount of paper/cardboard in MSW incinerated (wet basis).

Activity data for incineration of paper/cardboard (MSW) (dry basis)
= Volume of paper/cardboard incinerated (wet basis)
× (1 - Percentage of water content in paper/cardboard)

➢ ***Nappy***

Although nappy in Japan's municipal waste is generally classified into paper or textile, the incinerated amount is not clearly distinguished from these categories. Therefore, conservatively considering as the independent activity from paper/cardboard and textile incinerated, the amount of domestic production of nappies is applied as the activity data for nappy incinerated.

Activity data for incineration of nappy (MSW) (dry basis)
= Amount of domestic production of nappies (dry basis)

- ***Amount of domestic production of nappies***

The amount of domestic production of nappies is derived from the reported amount of nappies for adult and infant (dry basis) on the JHPIA news published by Japan Hygiene Products Industry Association.

➢ ***Activity data***

Activity data calculated by methodologies above is shown in Table 7-35.

Table 7-35 Activity data to estimate CO_2 emissions from MSW incinerated (dry basis)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fossil-fuel derived plastics	kt / year (dry)	3,998	4,160	4,919	3,540	2,880	2,717	2,950	2,572	2,316	2,532	2,927	2,940	2,769
Synthetic textile	kt / year (dry)	476	531	473	592	705	600	759	850	776	681	598	579	587
Paper/cardboad	kt / year (dry)	9,157	9,916	10,863	11,193	10,647	10,534	9,907	9,150	9,447	9,796	10,187	9,881	9,822
Nappy	kt / year (dry)	272	333	340	475	497	520	526	531	576	584	627	670	716

- ***Percentage of Municipal Waste Incinerated at Municipal Incineration Facilities for Energy Recovery***

Percentage of municipal waste that is incinerated at municipal incineration facilities with energy recovery stands for the one being incinerated at the facilities actually supply electricity or heat outside of them. These values are obtained from the *State of Municipal Waste Treatment Survey* (Ministry of the Environment).

Table 7-36 Percentage of municipal solid waste incinerated at incineration facilities with energy recovery

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Without off-field power generation or heat utilization	%	53.7	55.6	61.1	68.4	67.9	67.4	68.4	66.1	66.9	65.2	67.7	66.4	66.4
With off-field power generation or heat utilization	%	46.3	44.4	38.9	31.6	32.1	32.6	31.6	33.9	33.1	34.8	32.3	33.6	33.6

2) CH_4

- ***Estimation Method***

CH_4 emissions from incinerator are estimated by multiplying the amount of MSW (wet basis) by incinerator method by each emission factor. CH_4 emissions from gasification melting furnace are estimated by multiplying the amount of MSW (wet basis) incinerated in gasification melting furnace by emission factors. Emissions from MSW with energy recovery are subtracted from the total emissions from this source and allocated to the waste sector.

$$E = \sum_i \left(EF_i \times A_i\right) \times \left(1 - R\right)$$

E : CH_4 emission from the incineration of MSW [kg-CH_4]

EF_i : Emission factor for incineration method i (or furnace type i) (wet basis) [kg-CH_4/t]

A_i : Amount of incinerated MSW by incineration method i (or furnace type i) (wet basis) [t]

R : Percentage of MSW incinerated at facilities with energy recovery

- ***Emission Factor***

➢ ***Incinerator***

In order to implement countermeasures against dioxins, the renovations, repairs, or rebuilding of incineration facilities took place in the latter half of 1990 through the first half of 2000 in Japan. There have been some improvements made in CH_4 emission factors from the facilities renovated or rebuilt in FY2000 and later, compared to the values obtained before then (Reference #18). Therefore, based on the survey (Reference #18) and expert judgment, for the CH_4 emission factors for incinerator by incinerator type (stoker furnace and fluidized bed incinerator) and incineration method (continuous incinerator, semi-continuous incinerator, and batch type incinerator) for the period FY2001 and before (Reference #7), and from FY2002 onward (Reference #18), respectively, different values are used. All the emission factors are established based on actual measurement survey.

In order to apply activity data based on the amount of incineration by incineration method, emission factors are established by incineration method (continuous incinerator, semi-continuous incinerator, and batch type incinerator) using the weighted average of fraction of the amount of incineration by incinerator type for each fiscal year. The Correction taking into account CH_4 concentrations in the atmosphere is not made to these emission factors.

➢ ***Gasification Melting Furnace***

Different emission factor is used for each furnace type (shaft furnace, fluidized bed, and rotary kiln) (Reference #18). Also, in order to apply activity data based on the total amount of incineration, emission factors are determined by taking the weighted average of the amount of incineration by gasification melting furnace type for each year.

Table 7-37 CH_4 emission factors by type of incineration method (MSW)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Continuous incinerator	g-CH_4/t	8.2	8.2	8.3	2.6	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.7	2.7
Semi-continuous incinerator	g-CH_4/t	69.6	69.6	75.1	19.9	20.7	20.9	21.0	20.6	20.9	20.8	21.1	20.9	20.9
Batch type incinerator	g-CH_4/t	80.5	80.5	84.1	13.2	13.2	13.3	13.2	13.4	11.6	11.6	11.6	11.7	11.7
Gasification melting furnace	g-CH_4/t	NA	NA	5.6	6.9	6.9	7.0	7.1	7.0	7.0	7.0	6.9	6.9	6.9

Source: Reference #6, 8, 18, 32, 57, 64

● ***Activity Data***

The activity data for CH_4 emissions for incinerator and gasification melting furnace are estimated by multiplying the amount of MSW incinerated (wet basis) provided in the *Cyclical Use of Waste Report* (publicized reports and the most current data from the reports prior to publication) by the fraction of incineration by incineration method of incinerator or gasification meting furnace provided by the *Waste Treatment in Japan*.

Table 7-38 Amount of incineration of MSW by incineration method

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Continuous incinerator	kt /year (wet)	26,215	29,716	32,749	32,246	31,962	30,840	29,426	28,444	27,603	27,892	28,702	28,246	27,285
Semi-Continuous Incinerator	kt /year (wet)	4,810	5,455	5,882	4,047	3,852	3,609	3,339	3,155	2,968	2,932	2,849	2,827	2,730
Batch type Incinerator	kt /year (wet)	5,643	4,328	3,131	1,562	1,470	1,369	1,346	1,144	1,078	1,057	1,061	970	937
Gasification melting furnace	kt /year (wet)	NO	NO	370	2,397	2,630	2,954	3,122	3,245	3,605	3,857	4,122	4,098	3,959

3) N_2O

● ***Estimation Method***

N_2O emissions from incinerator are estimated by multiplying the amount of MSW (wet basis) by incinerator method by each emission factor. N_2O emissions from gasification melting furnace are estimated by multiplying the amount of MSW (wet basis) incinerated in gasification melting furnace by emission factors. Emissions from MSW with energy recovery are subtracted from the total emissions from this source and allocated to the waste sector.

$$E = \sum_i \left(EF_i \times A_i\right) \times \left(1 - R\right)$$

E : N_2O emission from the incineration of MSW [kg-N_2O]

EF_i : Emission factor for incineration method i (or furnace type i) (wet basis) [kg-N_2O /t]

A_i : Amount of incinerated MSW by incineration method i (or furnace type i) (wet basis) [t]

R : Percentage of MSW incinerated at facilities with energy recovery

● ***Emission Factor***

➢ ***Incinerator***

Same as for CH_4 emissions estimation, for the N_2O emission factors for incinerator by type and by incineration method, different values are used for the period FY2001 and before (Reference #7), and

from FY2002 onward (Reference #18), respectively. In order to apply activity data based on the amount of incineration by incineration method, emission factors are established by incineration method (continuous incinerator, semi-continuous incinerator, and batch type incinerator) using the weighted average of fraction of the amount of incineration by incinerator type for each fiscal year calculated based on the *Waste Treatment in Japan*.

➢ ***Gasification Melting Furnace***

Different emission factor is used for each furnace type (shaft furnace, fluidized bed, and rotary kiln) (Reference #18). In order to apply the activity data based on the total amount of incineration, emission factors are established by taking the weighted average of the amount of incineration by gasification melting furnace type for each year calculated based on the *Waste Treatment in Japan.*

Table 7-39 N_2O emission factors by incineration types (MSW)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Continuous incinerator	g-N_2O/t	58.8	58.8	59.1	37.9	37.9	37.9	37.9	37.9	38.0	38.0	38.0	38.0	38.0
Semi-continuous incinerator	g-N_2O/t	56.8	56.8	57.3	71.5	72.8	73.1	73.3	72.7	73.2	73.1	73.4	73.1	73.1
Batch type Incinerator	g-N_2O/t	71.4	71.4	74.8	76.0	76.0	76.0	76.0	76.0	76.2	76.2	76.2	76.2	76.2
Gasification melting furnace	g-N_2O/t	NA	NA	16.9	12.0	11.3	11.5	11.1	11.2	11.5	11.9	11.7	11.7	11.7

Source: Reference #7, 8, 18, 32, 57, 64

● ***Activity Data***

The activity data for CH_4 emissions from incinerators and gasification melting furnaces are also applied for the activity data for N_2O emission from them.

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties in CO_2 emission factors are evaluated by using the 95% confidence interval of carbon content data in plastics. The uncertainties in CH_4 and N_2O emission factors are evaluated by using the 95% confidence interval in the actual measurement on the surveys for emissions factors. As for the uncertainties in activity data, the uncertainties in municipal solid waste data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-40 and Table 7-41.

Table 7-40 Uncertainty assessment for municipal solid waste on the category “waste incineration (5.C.1.-)” (CO_2)

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Plastics	CO_2	-2%	+2%	-10%	+10%	-10%	+10%	Quoted from “Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009”, a source of emission factors.	The uncertainty in municipal waste statistics based on expert judgment is applied.	Combined by using the formula for propagation of errors
Synthetic textile	CO_2	-2%	+2%	-10%	+10%	-10%	+10%	It is evaluated at the 95% confidence interval in actual measurement data of carbon content in synthetic textile.		
Paper/ cardboard	CO_2	-100%	+400%	-10%	+10%	-101%	+400%	It is evaluated by combining the 95% confidence interval in actual measurement data of carbon content with the uncertainty of fossil-derived carbon ratio in 2006GLs as default value.		
Nappy	CO_2	-23%	+29%	-10%	+10%	-25%	+30%	The uncertainty is evaluated according to the default uncertainty assessment in 2006GLs because the emission factor for this item is the default value in 2006GLs.		

Table 7-41 Uncertainty assessment for municipal solid waste on the category "waste incineration (5.C.1.-)" (CH_4 and N_2O)

Item		GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
			(-)	(+)	(-)	(+)	(-)	(+)			
No corresponding category (CH_4)	Continuous incineration /Stoker furnace	CH_4	-39%	+39%	-10%	+10%	-40%	+40%	The uncertainty is quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.	The uncertainty based on expert judgment in municipal waste statistics is applied.	Combined by using the formula for propagation of errors
	Continuous incineration /Fluidized bed furnace	CH_4	-100%	+719%	-10%	+10%	-100%	+719%			
	Semi-continuous incineration/ Stoker furnace	CH_4	-82%	+82%	-10%	+10%	-83%	+83%			
	Semi-continuous incineration / Fluidized bed furnace	CH_4	-100%	+162%	-10%	+10%	-100%	+162%			
	Batch-type incineration/ Stoker furnace	CH_4	-75%	+75%	-10%	+10%	-76%	+76%			
	Batch-type incineration /Fluidized bed furnace	CH_4	-100%	+394%	-10%	+10%	-100%	+394%			
	Gasification melting furnace/ Shaft furnace	CH_4	-100%	+203%	-10%	+10%	-100%	+203%			
	Gasification melting furnace/ Fluidized bed furnace	CH_4	-100%	+133%	-10%	+10%	-100%	+134%			
	Gasification melting furnace/ Rotatory kiln	CH_4	-54%	+54%	-10%	+10%	-55%	+55%			
No corresponding category (N_2O)	Continuous incineration /Stoker furnace	N_2O	-34%	+34%	-10%	+10%	-35%	+35%	The uncertainty is quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.	The uncertainty based on expert judgment in municipal waste statistics is applied.	Combined by using the formula for propagation of errors
	Continuous incineration /Fluidized bed furnace	N_2O	-98%	+98%	-10%	+10%	-99%	+99%			
	Semi-continuous incineration/ Stoker furnace	N_2O	-82%	+82%	-10%	+10%	-82%	+82%			
	Semi-continuous incineration / Fluidized bed furnace	N_2O	-64%	+64%	-10%	+10%	-64%	+64%			
	Batch-type incineration/ Stoker furnace	N_2O	-100%	+111%	-10%	+10%	-100%	+111%			
	Batch-type incineration /Fluidized bed furnace	N_2O	-100%	+133%	-10%	+10%	-100%	+134%			
	Gasification melting furnace/ Shaft furnace	N_2O	-45%	+45%	-10%	+10%	-46%	+46%			
	Gasification melting furnace/ Fluidized bed furnace	N_2O	-100%	+252%	-10%	+10%	-100%	+252%			
	Gasification melting furnace/ Rotatory kiln	N_2O	-87%	+87%	-10%	+10%	-88%	+88%			

- ***Time-series Consistency***

Because data on the amount of waste incinerated by type of waste are not available for years prior to FY1997, the data are estimated by using the total incinerated amount of MSW for each year and the ratio of amount of waste incinerated by waste type for FY1998. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Identifying the additional uses of biomass-based plastic products, emission estimates were recalculated.
- Updating the statistical data, emission estimates were recalculated. For detail, see the section "7.1.5. General Recalculations for Emissions from Waste Sector".
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.1.2. Industrial Waste (5.C.1.-)

a) Category Description

This category covers CO_2, CH_4 and N_2O emissions from incineration of industrial waste without energy recovery by each waste type and the emissions are reported in the corresponding category either "biogenic, industrial solid waste (ISW)", "biogenic, non-fossil liquid waste", "biogenic, sludge" "non-biogenic, industrial solid waste" or "non-biogenic, fossil liquid waste" (see Table 7-22).

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions of fossil-fuel derived CO_2 from this source are calculated by using the volume of waste oil, plastic, and paper/cardboard incinerated, Japan's country-specific emission factors, and the percentage of incinerated industrial waste with energy recovery at industrial waste incineration facilities in accordance. Note that since it is difficult to estimate percentages of water content in waste oil and plastic in industrial waste, the emission factors for these sources are identified as wet basis. Also, since industrial textiles does not include synthetic textile under the regulation of the Waste Disposal and Public Cleansing Law, the industrial textiles is regarded as waste natural fiber: thus the CO_2 emissions from incineration of industrial textiles are not included in national total because these emissions are biogenic-origin.

$$E_i = EF_i \times A_i \times (1 - R_i)$$

E_i : CO_2 Emissions from incineration of waste type i [kg-CO_2]

EF_i : Emission factor for incineration of waste type i [kg-CO_2/t]
(wet basis for waste oil and plastic; dry basis for paper/cardboard)

A_i : Amount of incinerated waste type i [t]
(wet basis for waste oil and plastic; dry basis for paper/cardboard)

R_i : Percentage of industrial waste incinerated at facilities with energy recovery (for waste type i)

- ***Emission Factor***

➢ ***Equation***

In accordance with the approach taken by the *2006 IPCC Guidelines*, emission factor is calculated by multiplying the carbon content of each type of waste by the incineration rate for incineration facilities.

- ***Fossil-fuel derived waste oil, plastic***

$$EF_i = CF_i \times OF \times 44/12$$

EF_i : Emission factor for the incineration of waste type *i* (wet basis) [kg-CO_2/t]
CF_i : Carbon content in waste type *i* (wet basis) [%]
OF : Oxidation factor [%]

- ***Paper/cardboard***

$$EF_i = CF_i \times FCF_i \times OF \times 44/12$$

EF_i : Emission factor for the incineration of fossil-fuel derived components in paper/cardboard (dry basis) [kg-CO_2/t]
CF_i : Carbon content in paper/cardboard (dry basis) [%]
FCF_i : Fossil-fuel derived fraction in carbon in paper/cardboard [%]
OF : Oxidation factor [%]

➢ ***Carbon Content***

Carbon content in waste oil is deemed to be 80% based on the factor of 0.8 [t-C/t] given in *the Report on Estimation of CO_2 Emissions in Japan* (Environmental Agency, 1992) (Reference #5). Carbon content in plastic is deemed to be 70% based on the factor of 0.7 [t-C/t] given in the said report.

For the carbon content of paper/cardboard, the carbon content of default value in the *2006 IPCC guidelines*, as same as the value in municipal solid waste.

Table 7-42 Carbon contents of waste oil, plastic and Paper/cardboard in industrial waste

Item	Carbon contents	Remarks	References
Waste oil	80%	wet basis	Reference #5
Plastics	70%	wet basis	Reference #5
Paper/ cardboard	46 %	dry basis	*2006 IPCC Guidelines*

➢ ***Fossil-fuel derived fraction in carbon in paper/cardboard in industrial waste***

For the fossil-fuel derived fraction in carbon in paper/cardboard in industrial waste, the default value of 1% in the *2006 IPCC Guidelines* are applied as same as for paper/cardboard in municipal solid waste.

➢ ***Oxidation factor***

The default value of 100% given in the *2006 IPCC Guidelines* is used.

➢ ***Emission factor***

Emission factors calculated by methodologies above are shown in Table 7-43.

Table 7-43 Emission factors for fossil-fuel derived fraction of waste oil, plastics and paper/cardboard in industrial waste

Item	Unit	Emission factor
Waste oil	kg-CO_2/t (wet)	2,933
Plastics	kg-CO_2/t (wet)	2,567
Paper/cardboard	kg-CO_2/t (dry)	17

- ***Activity Data***

For the activity data for CO_2 emissions from the incineration of waste oil, plastics and paper/cardboard in industrial waste, the amount of incineration provided by the *Cyclical Use of Waste Report* is used. However, the amount of incineration provided in this report includes the amount of incineration of specially controlled industrial waste which is separately reported under "Incineration of Specially Controlled Industrial Waste" (see the next section), thus it is subtracted from the activity data from this source. Details of methodologies to estimate activity data are shown below.

Activity data for the incineration of waste fossil-fuel derived oil (wet basis)

= Amount of waste oil incinerated in industrial waste
× (1 – Fraction of waste oil from animal and vegetable origin*)
– Amount of waste oil incinerated in specially controlled industrial waste**

* : From the survey conducted by the Ministry of Environment
** : All the waste oil in specially controlled industrial waste to be estimated for emissions are waste fossil-fuel derived oil.

Table 7-44 Fraction of waste oil from animal and vegetable origin

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Fraction of waste animal and vegetable oil	%	2.6	3.5	4.5	5.4	5.6	5.8	6.0	6.0	6.0	6.0	6.0	6.0	6.0

Activity data for the incineration of plastics (IW) (wet basis)

= (Amount of plastics incinerated in industrial waste
- Amount of plastics incinerated in specially controlled industrial waste)
× Fossil-fuel derived fraction of plastics* (wet basis)

*: Fossil-fuel derived fraction of plastics in industrial waste plastics incinerated is estimated in the same way as indicated in "7.4.1.1. Municipal Solid Waste (5.C.1.-) b) 1) CO_2". See also Table 7-33. Note it is assumed that activity data for plastics (IW) incinerated does not include plastic bottles unlike MSW plastics.

Activity data for the incineration of paper/cardboard (IW) (dry basis)

= {Amount of paper/cardboard incinerated in industrial waste
– (Amount of infectious waste incinerated in specially controlled industrial waste
– Amount of plastic incinerated in specially controlled industrial waste)}
× (1 – percentage of waste content in paper or cardboard in industrial waste*)

*: Percentage of water content in paper/cardboard in industrial waste is given the value 15% (see Table 7-10).

For more detail of activity data estimated, see Table 7-47.

- ***Percentage of Industrial Waste Incinerated at Industrial Incineration Facilities for Energy Recovery (by type)***

Percentage of industrial waste that is incinerated at industrial incineration facilities with energy recovery stands for the one being incinerated at the facilities actually supply electricity or heat outside of them. The values are obtained from the *FY2007 Survey of Industrial Waste Treatment Facilities* (Ministry of the Environment).

In Japan, industrial incineration facilities are installed mainly by private sector waste disposal enterprises. In comparison with the municipal waste incinerators installed primarily by municipal governments, energy recovery (for use in power generation and as a heat source) has not yet been so popular. The percentage for the industrial waste category is therefore smaller.

Table 7-45 Percentage of IW incinerated at incineration facilities with energy recovery

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Waste oil [1)]	%	0.6	0.7	0.6	2.5	2.5	2.3	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Plastics	%	1.4	1.4	4.1	6.6	7.2	16.8	9.7	9.7	9.7	9.7	9.7	9.7	9.7
Wood [2)]	%	0.2	0.8	1.1	1.5	1.8	4.4	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Sludge [3)]	%	0.9	0.8	1.0	1.1	1.6	0.9	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Other [4)]	%	0.2	0.8	1.1	1.5	1.8	1.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Note:
1） “Waste oil” includes fossil-fuel derived/animal and vegetable oil.
2） “Wood” includes paper/ cardboard and wood.
3） Not applicable for “sewage sludge”.
4） “Other” includes textiles (natural fiber), and animal and vegetable residues/animal carcasses.

2) CH_4

- ***Estimation Method***

Emissions of methane from this source have been calculated by multiplying the volume of industrial waste incinerated by Japan’s country specific emission factor and by percentage of industrial waste incinerated at incineration facilities with energy recovery.

$$E = \sum_j \left\{ EF_j \times A_j \times \left(1 - R_j\right) \right\}$$

E : Emission of methane from the incineration of industrial waste [kg-CH_4]

EF_j : Emission factor for waste type j (wet basis) [kg-CH_4/t]

A_j : Incinerated amount of waste type j (wet basis) [t]

Rj : Percentage of industrial waste j incinerated at facilities with energy recovery

- ***Emission Factor***

Based on expert judgment which takes into account the countermeasures against dioxin emissions from incinerators, for the emission factors by waste type for the period FY1990 - FY2001 (Reference #7) and from FY2002 onward (Reference #18), respectively, different values are used. These emission factors are established based on actual measurement survey. The correction taking into account CH_4 concentrations in the atmosphere is not made to these emission factors. The emission factor for paper/cardboard or wood in the Reference #7 and Reference #18 is substituted for the emission factor for textiles (natural fiber), and animal and vegetable residues/animal carcasses.

Table 7-46 CH_4 emission factors for industrial waste by type

Item	Unit	FY1990-2001	FY2002 onward
Waste oil (fossil-fuel derived/animal and vegetable)	g-CH_4 /t	4.8	4.0
Plastics	g-CH_4 /t	30	8.0
Paper/cardboard	g-CH_4 /t	22	225
Wood	g-CH_4 /t	22	225
Textiles (natural fiber)	g-CH_4 /t	22	225
Animal and vegetable residues/animal carcasses	g-CH_4 /t	22	225
Sludge	g-CH_4 /t	14	1.5
Other than sewage sludge	g-CH_4 /t	14	1.5

Source: Reference # 6, 7, 18, 33, 57

- ***Activity Data***

The volume of waste incinerated (wet basis) by waste type is used as the activity data for CH_4 emissions from the incineration of industrial waste.

➢ ***Paper, Wood, Textiles (natural fiber) and Animal and Plant Residues/Animal Carcasses:***

The volume of waste incinerated for each type is obtained from the *Cyclical Use of Waste Report*. Animal and vegetable residues/animal carcasses waste is defined as the sum of items "animal and vegetable residues" and "animal carcasses" in the said reference.

➢ ***Sludge***

Activity data is taken as the aggregate of the values obtained from the "Volume of Other Incinerated Organic Sludge" section in the *Cyclical Use of Waste Report*, and the "Volume of Incinerated Sewage Sludge" reported in a survey by the Ministry of Lands, Infrastructure, Transport and Tourism.

➢ ***Waste Oil (Fossil-fuel derived/Animal and Vegetable) and Plastic***

The activity data for waste oil and plastic are provided by the *Cyclical Use of Waste Report.* Because the values provided by this report include the amount of specially-controlled industrial waste which is allocated to the category of specially-controlled industrial waste (5.C.1.-), it is subtracted from the total amount to avoid double counting. Unlike the activity data for CO_2 emissions, waste fossil-fuel derived oil and also waste animal and vegetable oil are included for the estimation of activity data from this source. Note activity data for plastic includes biomass-based plastic.

Table 7-47 Incinerated industrial waste by waste types

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Waste fossil-fuel derived oil	kt / year (wet)	1,258	1,498	1,646	1,493	1,435	1,445	1,283	1,104	1,467	1,410	1,546	1,297	1,343
Waste animal and vegetable oil	kt / year (wet)	40	69	103	115	115	120	139	113	121	110	117	103	109
Plastics (Fossil-fuel derived)	kt / year (wet)	842	1,794	1,780	1,808	1,745	1,919	2,118	1,490	1,701	1,508	1,629	1,774	1,765
Biomass-based plastics	kt / year (wet)	NO	NO	NO	NO	NO	NO	0.5	0.3	2.3	2.6	3.2	3.6	4.0
Paper/cardboad	kt / year (wet)	335	712	718	323	322	141	494	299	292	225	349	152	134
Wood	kt / year (wet)	2,679	4,744	3,114	1,865	1,660	1,659	1,313	1,283	1,101	1,135	1,181	1,388	1,173
Textiles (Natural fiber)	kt / year (wet)	31	49	50	43	36	36	33	26	24	26	24	35	35
Animal and vegetable residues/animal carcasses	kt / year (wet)	77	125	272	167	186	154	220	181	190	184	153	151	135
Sewage sludge	kt / year (wet)	3,060	3,827	4,300	4,988	4,861	4,820	4,792	4,731	4,694	4,734	4,817	4,934	4,753
Sludge other than sewage	kt / year (wet)	1,972	2,023	2,071	2,288	2,253	2,275	2,082	2,106	2,010	2,020	1,713	1,954	1,954

3) N_2O

- ***Estimation Method***

Emissions of N_2O from this source are calculated separately for the major emission source, sewage sludge, and the waste other than sewage sludge. With respect to sewage sludge, emission factors are set by type of flocculants and furnaces; and the ones for "high-molecular-weight, flocculant fluidized bed incinerator" are further determined by the incineration temperatures. Emissions from the industrial waste other than sewage sludge are estimated by multiplying the volume of waste

incinerated by Japan's country-specific emission factor. Among those emissions, the ones to be reported in the waste sector are calculated by multiplying the percentage of industrial waste incinerated at the industrial waste incineration facilities with energy recovery.

$$E = \sum \left\{ EF_j \times A_j \times \left(1 - R_j\right) \right\}$$

E : Emission of nitrous oxide from the incineration of industrial waste [kg-N_2O]

EF_j : Emission factor for waste type j (wet basis) [kg-N_2O /t]

A_j : Incinerated amount of waste type j (wet basis) [t]

R_j : Percentage of industrial waste j incinerated at facilities with energy recovery

- ***Emission Factor***

➢ ***Sewage Sludge***

Emission factor for N_2O emissions from sewage sludge incineration are determined by taking a weighted average of actually measured emission factors of N_2O at each incineration facility based on the survey on the volume of sewage sludge incinerated at the facilities conducted by the Ministry of Land, Infrastructure, Transport and Tourism. Since emission factors are different depending on the types of flocculants, incinerators, and furnace temperatures, they are established for each category as given in Table 7-48 (Reference #7).

Table 7-48 N_2O emission factors for sewage sludge incineration (wet basis)[a]

Type of flocculant	Type of incinerator	Combustion Temperature	Emission factor[1)] [g-N_2O/t]
High-molecular weight flocculant	Fluidized Bed Incinerator	Normal temperature combustion (around 800˚C)	1,508
	Fluidized Bed Incinerator[2)]	High temperature combustion (around 850˚C)	645
	Multiple Hearth	－	882
Other	－	－	
Lime Sludge	－	－	294
－	- Multiple hearth air injection incineration method fluidized bed incinerator - Two-stage incineration method circulating fluidized bed incinerator - Stoker furnace	High temperature combustion (around 850˚C)	263
－	Carbonization furnace for solid fuel production	－	31.2

Source: Reference #19, 35, 36, 37, 37, 65, 66, 72, 73

Note:

1） The same emission factors are used for all the reporting years.

2） Excludes multiple hearth air injection incineration method fluidized bed incinerator and two-stage incineration method circulating fluidized bed incinerator.

➢ ***Waste other than Sewage Sludge***

Based on expert judgment which takes into account the countermeasures against dioxin emissions from incinerators, for the emission factors by waste type for the period FY1990-FY2001 (Reference #7) and from FY2002 onward (Reference #18), respectively, different values are used. These emission factors are established based on actual measurement survey. The correction taking into account CH_4 concentrations in the atmosphere is not made to these emission factors.

The emission factor applied for paper/cardboard or wood is also used for textiles (natural fiber) and animal and vegetable residues/animal carcasses in the Reference #7 and Reference #18.

Table 7-49 N_2O Emission factors for industrial waste by type (wet basis)

Item	Unit	FY1990-2001	From FY2002 onward
Waste oil (fossil-fuel derived/animal and vegetable)	g-N_2O /t	12	62
Plastics	g-N_2O /t	180	15
Paper/cardboard	g-N_2O /t	21	77
Wood	g-N_2O /t	21	77
Textiles (natural fiber)	g-N_2O /t	21	77
Animal and vegetable residues/animal carcasses	g-N_2O /t	21	77
Sludge (excluding sewage sludge)	g-N_2O /t	457	99

Source: Reference #6, 18, 33, 57, 65, 70, 71, 72, 73, 78, 79

- ***Activity Data***

➢ ***Sewage Sludge***

Data in the "volume of incinerated sewage sludge, by flocculants and by incinerator types" reported in a survey by the Ministry of Lands, Infrastructure, Transport and Tourism are used as activity data (wet basis).

Table 7-50 Amount of sewage sludge incinerated

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
High-molecular-weight flocculant Fluidized bed incinerator (nomal temp.)	kt / year (wet)	1,112	1,869	2,397	2,839	2,474	1,935	1,785	1,664	1,535	1,532	1,552	1,549	1,318
High-molecular-weight flocculant Fluidized bed incinerator (high temp.)	kt / year (wet)	128	219	723	1,469	1,781	2,355	2,470	2,508	2,581	2,587	2,641	2,644	2,644
High-molecular-weight flocculant multiple hearth	kt / year (wet)	560	656	572	102	88	69	56	64	61	52	43	40	NO
Lime sludge	kt / year (wet)	1,010	663	272	289	219	211	193	142	109	83	74	22	1
Other	kt / year (wet)	55	161	175	8	11	12	1	1	1	3	0.5	12	70
- Multiple hearth air injection/blowing incineration method fluidized bed incinerator, - Two-stage incineration method circulating fluidized bed incinerator, - Stoker furnace	kt / year (wet)	195	259	161	280	288	238	233	282	338	439	444	565	604
Carbonization furnace for solid fuel production	kt / year (wet)	NO	NO	NO	NO	NO	NO	55	71	70	39	63	103	116

➢ ***Industrial Waste other than Sewage Sludge***

Activity data (wet basis) is determined in the same manner as for the CH_4 emissions from industrial waste, with the exception that the "volume of other incinerated organic sludge" is used as activity data for the sludge (excluding sewage sludge).

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties in CO_2 emission factors are evaluated by using the 95% confidence interval of carbon content data in fossil fuel-based waste. The uncertainties in CH_4 and N_2O emission factors are evaluated by using the 95% confidence interval in the actual measurement on the surveys for emissions factors. As for the uncertainties in activity data, the uncertainties in industrial waste data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-51.

Table 7-51 Uncertainty assessment for industrial waste on the category "waste incineration (5.C.1.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Waste oil	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in municipal waste plastics is substituted based on expert judgment.	The uncertainty based on expert judgment in industrial waste statistics is applied.	Combined by using the formula for propagation of errors
	CH_4	-100%	+181%	-30%	+30%	-104%	+184%	The uncertainty is quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.		
	N_2O	-76%	+76%	-30%	+30%	-81%	+81%			
Plastics	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in municipal waste plastics is substituted based on expert judgment.		Combined by using the formula for propagation of errors
	CH_4	-100%	+216%	-30%	+30%	-104%	+218%	The uncertainties are quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.		
	N_2O	-44%	+44%	-30%	+30%	-53%	+53%			
Paper/card board	CO_2	-100%	+400%	-30%	+30%	-104%	+401%	It is evaluated by combining the 95% confidence interval in actual measurement data of carbon content with the uncertainty of fossil-derived carbon ratio in 2006GLs as default value.		Combined by using the formula for propagation of errors
Paper/card board or wood	CH_4	-100%	+412%	-30%	+30%	-104%	+413%	The uncertainty is quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.		Combined by using the formula for propagation of errors
	N_2O	-64%	+64%	-30%	+30%	-71%	+71%			
Sludge	CH_4	-100%	+201%	-30%	+30%	-104%	+203%			Combined by using the formula for propagation of errors
	N_2O	-84%	+84%	-30%	+30%	-89%	+89%			
Textiles	CH_4	-100%	+412%	-30%	+30%	-104%	+413%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in paper/card board or wood is substituted based on expert judgment.		Combined by using the formula for propagation of errors
	N_2O	-64%	+64%	-30%	+30%	-71%	+71%			
Animal and vegetable residues/ animal carcasses	CH_4	-100%	+412%	-30%	+30%	-104%	+413%			Combined by using the formula for propagation of errors
	N_2O	-64%	+64%	-30%	+30%	-71%	+71%			

- ***Time-series Consistency***

Emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Identifying the additional uses of biomass-based plastic products, emission estimates were recalculated.

- Updating the statistical data, emission estimates were recalculated. For detail, see the section "7.1.5. General Recalculations for Emissions from Waste Sector".
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.1.3. Specially Controlled Industrial Waste (5.C.1.-)

a) Category Description

The specially-controlled industrial waste includes wastes with properties, such as explosiveness, toxicity and infectivity, that may be harmful to human health or to living environment. Waste types in this category are indicated in the Table 7-52.

Table 7-52 Substance in incineration of specially-controlled industrial waste

Waste type	Substance
Flammable waste oil	Gasoline, Kerosene, Gas oil or diesel oil
Specified hazardous industrial waste oil	Trichlorethylene, tetrachlorethylene, dichloromethane, carbon tetrachloride, 1,2-dichloroethane, 1,1-dichloroethane, cis-1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,3 dichloropropene, thiuram, simazine, thiobencarb, benzene, selenium, 1,4-dioxane
Infectious waste plastic	Plastic
Infectious waste (except plastic)	Glasses, Textile, Paper

In this category, CO_2, CH_4, and N_2O emissions from incineration of specially-controlled industrial waste are estimated by each waste type and reported in the corresponding category either "Non-biogenic, Hazardous waste", Non-biogenic, Clinical waste" or "Biogenic, Clinical waste" (see Table 7-22).

Because the actual state of energy recovery from the incineration of specially-controlled industrial waste is not sufficiently understood, the emissions from specially-controlled industrial waste are reported entirely in "Waste Incineration (Category 5.C.)".

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions of CO_2 from the incineration of flammable waste oil, specified hazardous industrial waste oil and infectious waste plastic contained in specially-controlled industrial waste are estimated in accordance with the decision tree given in the *2006 IPCC Guidelines* (Page 5.9, Fig. 5.1) by using Japan's country-specific emission factors and the volume of waste incinerated.

- ***Emission Factor***

- ***Flammable waste oil***

Emission factors for waste oil in industrial waste is used for flammable waste oil in specially-controlled industrial waste, since the difference of carbon contents and oxidation factor in the two source categories is considered to be small.

- ***Specified hazardous industrial waste oil***

In accordance with the approach taken by the *2006 IPCC Guidelines*, emission factor for specified hazardous industrial waste oil is estimated by multiplying the carbon content of the item by the oxidation factor for incineration facilities.

$$EF = CF \times OF \times (1 - w) \times 44/12$$

EF : Emission factor for the incineration of specified hazardous industrial waste oil [kg-CO_2/t]
CF : Carbon content in specified hazardous industrial waste oil (dry basis) [%]
OF : Oxidation factor [%]
w : Percentage of water content in specified hazardous industrial waste oil [%]

Average carbon content in specified hazardous industrial waste oil (dry basis) is estimated using weighted average of carbon content in chemical formula of substances shown in Table X for incinerated substances based on the "report on the survey for the estimation of GHG emissions from specially-controlled industrial waste, Ministry of the environment" (FY2009 and FY2010). For the oxidation factor, the default value of 100% indicated in the *2006 IPCC Guidelines* is used. The percentage of water content in specified hazardous industrial waste oil is determined to be 5% by expert judgment.

- ***Infectious plastic***

For infectious plastic, the emission factors for incineration of plastics in industrial waste are substituted since the difference in terms of carbon contents and oxidation factor in the two source categories is considered to be small.

Table 7-53 CO_2 Emission factors for incineration of specially-controlled waste

Item	Unit	Emission factor
Flammable waste oil	kg-CO_2/t (wet)	2,933
Specified hazardous industrial waste oil	kg-CO_2/t (wet)	1,024
Infectious plastics	kg-CO_2/t (wet)	2,567

- ***Activity Data***

Generally, the amount of specially-controlled industrial waste incinerated obtained from the *Cyclical Use of Waste Report* is used as the activity data in and after FY2008. As for the past activity data which the survey data is not available, output volume of waste oil indicated in the *Report on Survey of Organizations in Industrial Waste Administration* (Water Supply Division, Health Service Bureau, the Ministry of Health and Welfare) is used on the assumption that the entire volume of waste oil and infectious plastic waste contained in specially-controlled industrial waste is incinerated. Details are shown below.

- ***Flammable waste oil***

The amount of specially-controlled industrial waste oil incinerated from the *Cyclical Use of Waste Report* is used as the activity data. Since the data includes both of incinerated amounts of flammable waste oil and specified hazardous industrial waste oil, the amounts of flammable waste oil are estimated by following equation. All the waste oil in specially-controlled industrial waste to be estimated for emissions is waste fossil-fuel derived oil.

$$A_{flammable\ oil} = A_{S\text{-}IW\ oil} - A_{s\text{-}hazardous\ oil}$$

$A_{flammable\ oil}$: Amount of flammable waste oil incinerated (wet basis) [t]
$A_{S\text{-}IW\ oil}$: Total amount of specially-controlled industrial waste oil incinerated (wet basis) [t]

$A_{s\text{-}hazard.\ oil}$: Amount of specified hazardous industrial waste oil incinerated (wet basis) [t]

- ***Specified hazardous industrial waste oil***

The activity data is obtained from following equation using the amount of specified hazardous industrial waste oil reduced in incineration from "report on the survey for the estimation of GHG emissions from specially-controlled industrial waste, Ministry of the environment" and Residual fraction of incinerated waste oil from the *Cyclical Use of Waste Report*.

$$A_{s\text{-}hazardous\ oil} = R_{s\text{-}hazardous\ oil} \times (1 + r)$$

$A_{s\text{-}hazardous\ oil}$: Amount of specified hazardous industrial waste oil incinerated (wet basis) [t]
$R_{s\text{-}hazard.\ oil}$: Amount of specified hazardous industrial waste oil reduced in incineration (wet basis) [t]
r : Residual fraction of incinerated waste oil [%]

- ***Infectious plastic***

The activity data is obtained from following equation using the amount of infectious waste incinerated from the *Cyclical Use of Waste Report* and Percentage of plastic content in infectious waste from *Waste Handbook* (reference #56). All of Infectious plastics are considered to be fossil-fuel derived.

$$A_{infectious\ plastics} = A_{infectious\ total} \times C_{infectious\ plastics}$$

$A_{infectious\ plastics}$: Amount of Infectious plastics incinerated (wet basis) [t]
$A_{infectious\ total}$:Total amount of infectious waste incinerated (wet basis) [t]
$C_{infectious\ plastics}$: Percentage of plastic content in infectious waste [%]

2) CH_4

- ***Estimation Method***

Emissions of CH_4 from the incineration of waste oil and infectious waste included in the specially controlled industrial waste are calculated by multiplying the volume of incinerated waste by type (wet basis) by Japan's country-specific emission factor.

- ***Emission Factor***

Because actual measurement data are not available, the emission factors for the incineration of industrial waste are used as substitutes for the emission factor for the specially-controlled industrial waste by type. Specifically, the substitute emission factors used are: the waste fossil-fuel derived oil in industrial waste for the flammable waste oil and specified hazardous waste oil; the plastic in industrial waste for the infectious plastic; and the paper/ cardboard and wood in industrial waste for the other infectious waste (biogenic).

- ***Activity Data***

- ***Flammable waste oil***

Activity data is the same as those used for CO_2 emission.

- ***Specified hazardous industrial waste oil***

Activity data is the same as those used for CO_2 emission.

- ***Infectious plastics***

Activity data is the same as those used for CO_2 emission.

- ***Infectious waste except plastics***

The activity data is obtained from similar equation to Infectious plastics, as follows.

$$A_{infectious\ plastics} = A_{infectious\ total} \times C_{infectious\ plastics}$$

$A_{infectious\ plastics}$: Amount of Infectious plastics incinerated (wet basis) [t]

$A_{infectious\ total}$:Total amount of infectious waste incinerated (wet basis) [t]

$C_{infectious\ plastics}$: Percentage of plastic content in infectious waste [%]

3) N_2O

- ***Estimation Method***

Emissions of N_2O from the incineration of waste oil and infectious waste in specially controlled industrial waste are calculated by multiplying the incinerated volume of each type of waste (wet basis) by Japan's country-specific emission factor.

- ***Emission Factor***

Because actual measurement data are not available, the N_2O emission factors for the incineration of industrial waste are used as substitutes for determining the emission factor for each type of specially controlled industrial waste. Specifically, the substitute emission factors used are: the waste oil in industrial waste for the flammable waste oil and specified hazardous waste oil; the plastics in industrial waste for the infectious plastics; and the paper/ cardboard and wood in industrial waste for the waste other than infectious plastics.

- ***Activity Data***

The same activity data used for CH_4 emissions is used.

Table 7-54 Amount of incineration of specially controlled industrial waste

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Flammable waste oil	kt (wet)	238	353	520	478	461	465	868	629	390	278	267	278	281
Specified hazardous industrial waste oil	kt (wet)	18	27	40	37	36	36	35	38	41	43	25	47	89
Infectious waste (plastic)	kt (wet)	78	128	167	169	163	180	131	143	154	176	131	133	136
Infectious waste (except plastics)	kt (wet)	105	172	225	228	220	242	91	99	106	121	90	92	94

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment is conducted as well as the assessment for the industrial waste incineration. As for the uncertainties in activity data, the uncertainties in specially-controlled industrial waste data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in Table 7-55.

Table 7-55 Uncertainty assessment for specially-controlled industrial waste on the category "waste incineration (5.C.1.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission/removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Specially-controlled industrial waste	CO_2	-2%	+2%	-60%	+60%	-60%	+60%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in municipal waste plastics is substituted based on expert judgment.	The uncertainty in specially-controlled industrial waste based on expert judgment is used.	Combined by using the formula for propagation of errors
	CH_4	-100%	+216%	-60%	+60%	-117%	+224%			
	N_2O	-44%	+44%	-60%	+60%	-74%	+74%			

- ***Time-series Consistency***

Since some basic data used for calculating activity data are available only for part of time series, consistent data over the time series are developed based on the estimation. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Updating the statistical data on the amount of specially-controlled waste, emission estimates were recalculated.
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.2. Open Burning of Waste (5.C.2.)

a) Category Description

In Japan, the Waste Disposal and Public Cleansing Law prohibits open burning of waste. Therefore, the emissions from this source category are reported as "NO".

7.4.3. Waste Incineration and Energy Use (Reported on Energy Sector) (1.A.)

7.4.3.1. Waste Incineration with Energy Recovery (1.A.)

a) Category Description

In this category, CO_2, CH_4, and N_2O emissions from the incineration of municipal and industrial waste with energy recovery are estimated and reported. The reporting category for the emissions is "Combined heat and power generation (Category 1.A.1.a.)" and the fuel types are classified as "Other fossil fuels" and/or "Biomass" as shown on the Table 7-23.

b) Methodological Issues

Methodologies similar to the ones used in "7.4.1.1. Municipal Solid Waste (5.C.1.-)" and "7.4.1.2. Industrial Waste (5.C.1.-)" are used. Emissions are calculated using the following equations:

1) CO_2

- ***Estimation Method***

➢ ***Municipal Solid Waste***

$$E = EF \times A \times R$$

E : Emission of CO_2 from waste incineration [kg-CO_2]
EF : Emission factor for incineration (dry basis) [kg-CO_2/t]
A : Amount of waste incinerated (dry basis) [t]
R : Percentage of municipal solid waste incinerated at incineration facilities with energy recovery

➢ ***Industrial Waste***

$$E = EF \times A \times R$$

E : Emission of CO_2 from waste incineration [kg-CO_2]
EF : Emission factor for waste incineration (wet basis) [kg-CO_2/t]
A : Amount of waste incinerated (wet basis) [t]
R : Fraction of industrial waste incinerated at industrial waste incineration facilities with energy recovery (by waste type)

2) CH_4 , N_2O

- ***Estimation Method***

➢ ***Municipal Solid Waste***

$$E = \sum_i \left(EF_i \times A_i \right) \times R$$

E : Emissions of CH_4 or N_2O from incineration of municipal solid waste [kg-CH_4], [kg-N_2O]
EF_i : Emission factor for municipal solid waste incinerator type i (wet basis) [kg-CH_4/t] [kg-N_2O/t]
A_i : Amount of municipal solid waste incinerated for incinerator type i (wet basis) [t]
R : Percentage of municipal solid waste incinerated at facilities with energy recovery

➢ ***Industrial Waste***

$$E = \sum_j \left(EF_j \times A_j \times R_j \right)$$

E : Emissions of CH_4 or N_2O from incineration of industrial waste [kg-CH_4] [kg-N_2O]
EF_j : Emission factor for industrial waste type j (wet basis) [kg-CH_4/t], [kg-N_2O/t]
A_j : Amount of industrial waste type j incinerated (wet basis) [t]
R_j : Fraction of industrial waste type j incinerated at industrial waste incineration facilities with energy recovery

- ***Activity Data Converted into Energy Units (Reference Value)***

Activity data converted into energy units to be reported in CRF is estimated as indicated below.

- ***Municipal Solid Waste***

$$A_E = A \times GCV \times R/10^6$$

A_E	: Calorific value of activity data of MSW [TJ]
A	: Total amount of MSW incinerated [kg (wet basis)]
GCV	: Gross calorific value of MSW [MJ/kg]
R	: Fraction of MSW incinerated at MSW incineration facility with energy recovery

Based on the actual measurement results obtained at municipality, the calorific value of MSW is 9.9 (MJ/kg).

- ***Industrial Waste***

$$A_E = \sum_j A_j \times GCV_j \times R \Big/ 10^6$$

A_E	: Calorific value of activity data of industrial waste [TJ]
A_j	: Amount of industrial waste type *j* incinerated [kg (wet basis)]
GCV_j	: Gross calorific value of industrial waste type *j* [MJ/kg]
R	: Fraction of industrial waste type *j* incinerated at industrial waste incineration facility with energy recovery

Calorific value of industrial waste is indicated in Table 7-60 (as referred to hereinafter).

c) Uncertainties and Time-series Consistency

Methodologies similar to the ones used in "7.4.1.1. Municipal Solid Waste (5.C.1.-)" and "7.4.1.2. Industrial Waste (5.C.1.-)" are used.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Same recalculations as the category waste incineration (without energy recovery) were conducted. For detail, see the paragraphs for category-specific recalculations on "7.4.1.1. Municipal Solid Waste (5.C.1.-)" and "7.4.1.2. Industrial Waste (5.C.1.-)".

f) Category-specific Planned Improvements

No improvements are planned.

7.4.3.2. Direct Use of Waste as Alternative Fuel (1.A.)

a) Category Description

In this category, CO_2, CH_4, and N_2O emissions from waste directly used as fuel are estimated and reported. The reporting category for the emissions for each type of waste is, according to its use as

fuel or raw material, either “Energy industries (Category 1.A.1.)” or “Manufacturing industries and Construction (1.A.2.)”. The fuel types are classified as “Other fossil fuels” and/or “Biomass” as indicated in Table 7-23.

Greenhouse gas emissions during the direct use of waste as a raw material, such as plastics used as reducing agents in blast furnaces or as a chemical material in coking furnaces, or use of intermediate products manufactured using the waste as a raw material, are estimated in this category. The waste used as raw material and the ones used as fuel are combined and expressed as “Raw Material/Fuel Use” in this section.

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions are estimated by multiplying the incinerated volume of each type of waste used as raw material or fuel by Japan’s country-specific emission factor. The wastes included in the estimation are the portions used as raw material or fuel of: plastics in MSW, plastics and waste fossil-fuel derived oil in industrial waste, and waste tires.

- ***Emission Factor***

Emission factors are established for the plastics from MSW that are used as chemical raw material in coke ovens and waste tires. The remaining emission sources used the emission factors for “7.4.1. Waste Incineration (without Energy Recovery) (5.C.1.)”.

Emission factors for this category	Plastics from municipal solid waste (as chemical raw material in coke ovens) and waste tires
Emission factors for incineration without energy recovery	Plastics from municipal solid waste (other than those used as chemical material in coke ovens) and industrial waste

Table 7-56 CO_2 Emission factors specially defined for this category

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MSW-coke oven	kg-CO_2/t(dry)	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434	1,434
Waste tire	kg-CO_2/t(dry)	1,867	1,794	1,799	1,746	1,738	1,730	1,734	1,738	1,759	1,744	1,743	1,744	1,736

- ***Activity Data***

For details of the amount of waste used as raw material or alternative fuels, see the7.4.3.2.a - 7.4.3.2.c.

Table 7-57 Use of waste as raw materials or fuels for CO_2 emissions

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MSW-plastics-oilification	kt (dry)	NO	NO	3	7	4	4	3	7	1	NO	NO	NO	NO
MSW-plastics-reducer in blast furnace	kt (dry)	NO	NO	25	37	39	33	17	28	27	26	26	30	27
MSW-plastics-chemical material in	kt (dry)	NO	NO	11	175	156	143	142	150	177	169	171	NO	18
MSW-plastics-gasification	kt (dry)	NO	NO	1	59	55	57	47	45	53	51	62	58	51
ISW-plastics (iron and steel)	kt (wet)	NO	NO	57	160	102	113	74	97	134	114	134	86	148
ISW-plastics (cement)	kt (wet)	NO	9	102	302	365	408	435	457	445	469	479	518	595
ISW-plastics (boiler)	kt (wet)	NO	NO	16	9	15	15	18	19	19	17	17	15	18
ISW-waste fossil-fuel derived oil (boiler)	kt (wet)	1,233	1,450	1,440	1,834	1,785	1,924	1,673	1,580	1,665	1,664	1,694	1,615	1,571
Waste tire	kt (dry)	282	471	580	498	546	577	593	547	573	560	545	549	584

Note: The amount of biomass-based plastics and waste animal and vegetable oil are not included in any of the items in the table.

2) CH_4, N_2O

- ***Estimation Method***

Emissions are estimated by multiplying the amount of each type of waste used as raw material or fuel by the country-specific emission factor.

- ***Emission Factor***

Emission factors for waste used as raw material and fuel are determined by multiplying the emission factor for applicable types of furnaces by the calorific value of each waste type, and converting the result to the weight-based values. Table 7-58 shows the data used in the estimation.

Calculation of emission factor (wet basis)

= (Emission factor for each type of furnace [kg-CH_4/TJ], [kg-N_2O/TJ])
× (Calorific value of each waste type [MJ/kg]) / 1000

Table 7-58 Data used for the calculation of CH_4 and N_2O emission factors for wastes used as raw material and fuel

Item			Emission factor for furnaces and ovens (Energy sector)	Calorific value
Plastics from municipal solid waste		Plastic oil	Boilers (Heavy fuel oil A, gas oil, kerosene, naphtha, other liquid fuels)	Calorific value of plastic
Industrial waste	Plastics	Cement kilns	Other industrial furnaces (solid fuel)	Calorific value of plastic
		Boilers	CH_4: Boilers (wood, charcoal, and other solid fuel) N_2O: Fluidized-bed boilers (solid fuel)	
	Waste oil (fossil-fuel derived/animal and vegetable)	Boilers	Boilers (Heavy fuel oil A, gas oil, kerosene, naphtha, other liquid fuels)	Specific gravity of reclaimed oil/waste oil [1)]
	Wood	Boilers	CH_4: Boilers (wood, charcoal) N_2O: Boilers (other than fluidized-bed) (solid fuel)	Calorific value of wood [2)]
Waste tires		Cement kilns	Other industrial furnaces (solid fuel)	Calorific value of waste tires
		Boilers	CH_4: Boilers (Steam coal, coke, other solid fuels) N_2O: Boilers (other than fluidized-bed) (solid fuel)	
		Carbonization	Boilers (gas fuels)	
		Gasification	Other industrial furnaces (gas fuels) and other industrial furnaces (liquid fuels) [3)]	

Note:
1) Calorific value per unit volume is determined by dividing by the specific gravity of waste oil (0.9 kg/l) obtained from the Waste Handbook (1997).
2) Source: 1997 General Survey of Emissions of Air Pollutants
3) The percentage of substances recovered during the gasification of waste tires. A weighted average is calculated using the proportions of gas and oil (22% and 43%) reported in the Hyogo Eco-town documents.

Table 7-59 CH_4 and N_2O emission factors for the use of waste as raw material or fuel used in the Energy sector

Furnace type/Fuel type	CH_4 Emission factor [kg-CH_4/TJ]	N_2O Emission factor [kg-N_2O/TJ]
Boilers (Heavy fuel oil A, gas oil, kerosene, naphtha, other liquid fuels)	0.26	0.19
Boilers (gas fuels)	0.23	0.17
Boilers (steam coal, coke, other solid fuels)	0.13	
Boilers (wood, charcoal)	74.9	
Boilers (other than fluidized-bed) (solid fuels)		0.85
Other industrial furnaces (liquid fuel)	0.83	1.8
Other industrial furnaces (solid fuel)	13.1	1.1
Other industrial furnaces (gas fuel)	2.3	1.2

Note: Emission factors are from Chapter 3, Energy.

Table 7-60 Calorific Value of waste incinerated and used as raw material or fuel

Item		Unit	GCV	Source of calorific value
Waste oil (including reclaimed oil)		TJ/l	40.2	Reference #29; estimated with 0.9[kg/l] from Reference #56
Plastic		MJ/kg	29.3	Reference #29
Paper/ cardboard		MJ/kg	15.1	Reference #56 (dry basis); value is obtained by subtracting water content
Wood		MJ/kg	14.4	Reference #29
Textiles		MJ/kg	17.9	Reference #56 (dry basis) ; value is obtained by subtracting water content
Food waste(Animal and vegetable residues/animal carcasses)		MJ/kg	4.4	Reference #56 (dry basis) ; value is obtained by subtracting water content
Sludge (including sewage sludge)		MJ/kg	4.7	Reference #29 (dry basis) ; value is obtained by subtracting water content
Waste tires	2004 and before	MJ/kg	20.9	Reference #29
	2005 and later	MJ/kg	33.2	Reference #29
RDF		MJ/kg	18.0	Reference #29
RPF		MJ/kg	29.3	Reference #29

- ***Activity Data***

➢ ***Waste Used as Raw Material and Fuel***

Activity data are determined for each category using the wet-basis values (Table 7-61). For more details, see each section.

Table 7-61 Amount of waste used as raw material or fuel for CH_4 and N_2O emissions

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
MSW-oilification	kt (wet)	NO	NO	3	7	4	4	3	7	1	NO	NO	NO	NO
ISW-waste wood	kt (wet)	1,635	1,635	2,061	2,683	2,841	3,045	3,724	3,918	3,900	4,065	4,151	4,425	4,578
ISW-waste plastics (cement)	kt (wet)	NO	NO	NO	NO	NO	NO	435	457	445	469	479	518	595
ISW-waste plastics (boiler)	kt (wet)	21	14	16	9	15	15	18	19	19	17	17	15	18
IW-waste fossil-fuel derived/animal &	kt (wet)	1,233	1,450	1,440	1,834	1,785	1,924	1,673	1,580	1,665	1,664	1,694	1,615	1,571
Waste tire-cement baking furnace	kt (wet)	111	275	361	181	168	148	141	112	95	77	66	62	53
Waste tire-boiler	kt (wet)	119	126	75	12	11	11	12	9	8	6	6	6	2
Waste tire-pyrolysis furnace	kt (wet)	67	37	30	10	8	8	2	1	1	1	NO	NO	NO
Waste tire-gasification	kt (wet)	NO	NO	NO	27	34	42	48	48	49	45	45	44	50

Note: See Table 7-57 for the activity data for IW-plastic (cement manufacturer) and IW-plastic (boiler).

➢ ***Activity Data Converted into Energy Units (Reference Value)***

Activity data converted into energy units to be reported in CRF are calculated as indicated below.

Activity data converted into energy units
= (Amount of waste used as raw material or fuel [kg (wet basis)]
× Corresponding calorific value of waste [MJ/kg]) / 10^6

c) Uncertainties and Time-series Consistency

See the respective section.

d) Category-specific QA/QC and Verification

See the respective section.

e) Category-specific Recalculations

See the respective section.

f) Category-specific Planned Improvements

See the respective section.

7.4.3.2.a. Municipal Waste (Plastic) Used as Alternative Fuel (1.A.1 and 1.A.2)

a) Category Description

This category covers the emissions from municipal waste (plastic) used as alternative fuels. Plastics in MSW collected under the Containers and Packaging Recycling Law are processed into petrochemical, blast furnace reducing agent, chemical raw material in coke oven, and gasification to be used as alternative fuel or raw material. Note this category does not include emissions from plastic bottles incineration since collected plastic bottles in MSW are generally supplied for material recycle system.

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emission estimates are calculated by multiplying the amount of fossil-fuel derived plastic in MSW by each usage (petrochemical, blast furnace reducing agent, chemical raw material in coke oven, and gasification) by Japan's country-specific emission factor.

- ***Emission Factor***

For the emission factors for plastics in MSW in the usage of petrochemical, blast furnace reducing agent, and gasification, the same values applied in "7.4.1.1. Municipal Solid Waste (5.C.1.-) are applied. The emission factor for plastics used as chemical raw material in coke ovens is set as the volume of hydrocarbon that is used as chemical raw material and from which no CO_2 is emitted into the air by subtracting the percentage of carbon in the plastics that migrates to hydrocarbon oil in the coke oven (47.9%) from emission factor for plastics (MSW).

Calculation of the emission factor for plastics used as raw material in coke ovens (dry basis)
= (Emission factor for the incineration of plastics in municipal solid waste)

× [1 – (Fraction of carbon in plastics used as chemical raw material for coke ovens that migrates to hydrocarbon)]

- ***Activity Data***

The amount of plastics in MSW used as raw material or fuel by usage (wet basis) is estimated by the total amount collected by designated legal bodies and municipalities to be processed as raw material or fuel by usage (wet basis). The methodology to estimate activity data for this category is the same as that in the section "7.4.1.1. Municipal Solid Waste (5.C.1.-) b) 1) CO_2".Note that only fossil-fuel derived fraction of "plastics other than plastic bottles in MSW" are applied for this category since this category does not include emissions from plastic bottles incineration.

Amount of fossil-fuel derived plastics used as raw material or fuel by usage (dry basis)
= Amount of plastics used as raw material or fuel by usage (wet basis)
× (1 – Water content in plastics)
× Fossil-fuel derived fraction of plastics other than plastic bottles in MSW

- ***The Amount of Plastics in MSW Used as Raw Material or Fuel by Usage (Wet Basis)***

Processing of plastics collected by designated legal bodies

The amount of the plastics in MSW collected by designated legal bodies into raw material and fuel is determined from the amount reported (pyrolytic oil: petrochemical, blast furnace reducing agent, chemical raw material in coke-oven, syngas, and gasification) in the "Plastic Containers and Packaging (Other Plastics, Food Trays)" section of the *Statistics of Commercial Recycling of Plastics (Recycling)* compiled by the Japan Containers and Packaging Recycling Association. Usage in products that do not emit CO_2 is deducted.

Processing of plastics collected by municipalities

The amount of plastics in MSW collected by municipalities and processed into raw material or fuel is calculated as indicated below.

Amount of plastics in MSW collected by municipalities and processed into raw material or fuel
= (Amount of all plastics that are commercially recycled under the Plastic Containers and Packaging Recycling Law (wet basis)[1]

– Amount of plastics (wet basis) that is commercially recycled through designated legal bodies)[2]
×Percentage of commercially recycled plastics by recycling method[3]
×Percentage of commercially recycled plastic products by recycling method[4] (The percentage for designated legal bodies is substituted for the value for municipalities.)

[1]: Amount of plastics commercially recycled under the Plastic Containers and Packaging Recycling Law (wet basis)
The results of the selective collections by municipalities and commercial recycling under the Plastic Containers and Packaging Recycling Law are determined from Annual Recycling Statistics by the Waste Management and Recycling Department of the Ministry of the Environment.

[2]: Amount of plastics commercially recycled through designated legal body channels (wet basis)

The amount is determined from the "Actual Collection of Plastic Containers and Packages" section of the Statistics of Commercial Recycling of Plastics (Recycling).

[3]: Percentage of commercially recycled plastics by recycling method

The rates are obtained from the percentages for various methods of commercial recycling of the plastics collected through municipal channels in the Results of the 2001 Questionnaire to Municipalities on Waste Plastic Processing compiled by the Plastic Waste Management Institute.

[4]: Percentage of commercially recycled plastic products by recycling method

The values for the commercial recycling of the plastics collected through the municipal channels are substituted for the percentage of commercially recycled plastic products collected through designated legal body channels. The percentages are calculated by dividing the amounts of commercially recycled plastic products by various recycling methods, which are established in the activity data for recycling through designated legal body channels, by the amount of commercially recycled plastics. The amount of commercially recycled plastics by each of the recycling methods is calculated by multiplying the amount of plastics commercially recycled through designated legal body channels, by the percentage of commercially recycled plastics by recycling method obtained from the Assessment and Deliberation of the Plastic Containers and Packaging Recycling Law, the Japan Containers and Packaging Recycling Association.

- ***Water Content Ratio***

Water content ratio of 4% is determined based on the data provided by the *Japan Containers and Packaging Recycling Association*.

- ***Fossil-fuel Derived Fraction of Plastics other than plastic bottles in MSW***

See Table 7-33 in the section "7.4.1.1. Municipal Solid Waste (5.C.1.-)."

2) CH_4, N_2O

For estimation method and emission factors, see the section "7.4.3.2. Direct Use of Waste as Alternative Fuel (1.A.)". The amount of plastics used as raw material or fuel by usage (wet basis) is determined by the total amount collected by designated legal bodies and municipalities to be processed as raw material and fuel by usage (wet basis); this value includes the amount of biomass-based plastics consumed.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment is conducted as well as assessment in the category of the municipal waste incineration. Details of the uncertainty assessment on this category are shown in the Table 7-62.

Table 7-62 Uncertainty assessment for municipal waste plastics used as alternative fuels (1.A.1 and 1.A.2)

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Plastics	CO_2	-2%	+2%	-10%	+10%	-10%	+10%	The equivalent assessment of the uncertainty in municipal waste plastics in "5.C Incineration" is used.	The uncertainty in municipal waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	CH_4	-39%	+39%	-10%	+10%	-40%	+40%	The equivalent assessment of the uncertainty in municipal waste in "5.C Incineration" is used.		
	N_2O	-34%	+34%	-10%	+10%	-35%	+35%			

- ***Time-series Consistency***

Time series consistency in emission estimates has been ensured. However, the statistical data for activity data have been available since FY2000 because the use of waste as alternative fuel or raw material was not a common practice prior to FY2000 in Japan.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Identifying the additional uses of biomass-based plastic products, CO_2 emission estimates were recalculated.
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.3.2.b. Industrial Waste (Plastics, Waste Oil, and Wood) Used as Alternative Fuels (1.A.2.))

a) Category Description

This category covers greenhouse gas emissions from industrial waste (plastics, waste oil, and wood) used as raw material or alternative fuels.

b) Methodological Issues

1) CO_2

- ***Estimation Method and Emission Factor***

Emissions are estimated by multiplying the amount of fossil-fuel derived plastics incinerated used as raw material or fuel and waste fossil-fuel derived oil used as raw material or alternative fuels by emission factor used for incineration of industrial waste.

- ***Activity Data***

➢ ***Plastics***

Estimated activity data are the amounts of plastics (wet basis) in industrial waste used as raw material or fuel in steel industry, chemical industry, paper industry, cement Manufacturer, and automobile manufacturer. The amount of plastics in industrial waste used as raw material or fuel in each industry is provided by the following data sources: for steel industry, the *Current State of Plastics Waste Recycling and Future Tasks* published by the Japan Iron and Steel Federation; for cement manufacturing industry, from the *Cement Handbook* published by the Japan Cement Association; for chemical industry, paper industry, and automobile manufacturer, the amount of plastics used for fluid bed boiler provided by the Japan Chemical Industry Association, the Japan Paper Association, the Japan Automobile Manufacturers Association. The fossil-fuel derived fraction in industrial waste

plastics is estimated in the same way as indicated in "7.4.1.2. Industrial Waste (5.C.1.-) 7.4.1.2. b)1) CO_2".

➢ ***Waste Fossil-fuel derived Oil***

Activity data is obtained from following sources:

The amount of waste oil indicated as "Fuel Usage" of "Direct Recycle Usage" and "Recycle Usage after Treatment" of industrial waste provided by the *Cyclical Use of Wastes Report*

In the estimation method for activity data, this item is subtracted the amount of biogenic-origin waste oil indicated as "Fraction of Animal and Vegetable Origin Waste Oil" provided by the survey conducted by the Ministry of the Environment. The data for FY1997 and before are estimated by using the trend of the amount of incinerated industrial waste oil.

The amount of recycled heavy oil products indicated in the *Lubricant Recycle Handbook*, Japan Lubricating Oil Society.

This item is assumed as fossil-fuel derived completely. The data for FY2001 and before are estimated by using the trend of the amount of incinerated industrial waste oil.

2) CH_4, N_2O

● ***Estimation Method and Emission Factor***

See the section "7.4.3.2. Direct Use of Waste as Alternative Fuel (1.A.)"

● ***Activity Data***

➢ ***Plastics***

Estimated activity data are the amounts of plastics used for cement kilns and boilers. Out of the activity data used for CO_2 emission estimates from this source, the amount used as raw materials and fuels in chemical industry, paper industry, cement manufacturer, and automobile manufacturer are used for CH_4 and N_2O emission estimates. Because blast furnace gas generated from steel industry is entirely recovered and not included in the activity data.

➢ ***Waste Oil (Fossil-fuel derived / Animal and Vegetable)***

The amount of waste oil used as fuel for boilers was obtained from the amount of waste oil indicated as "Fuel Usage" of "Direct Recycle Usage" and "Recycle Usage after Treatment" of industrial waste provided by the *Cyclical Use of Wastes Report*¸ and the amount of recycled heavy oil products indicated in the *Lubricant Recycle Handbook*, Japan Lubricating Oil Society.

Unlike the activity data for CO_2 emissions, waste fossil-fuel derived oil and also waste animal and vegetable oil are included for the estimation of activity data from this source.

➢ ***Wood***

The amount of usage of wood as raw material or fuel is obtained from the "fuel usage" in the "direct recycle usage" and the "fuel usage" in the "recycle usage after treatment" in the *Cyclical Use of Waste Report*. The values before FY1997 are estimated by using the average value in the period of FY1998-2002.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment is conducted as well as assessment in the category of the industrial waste incineration. Details of the uncertainty assessment on this category are shown in the Table 7-63.

Table 7-63 Uncertainty assessment for industrial waste plastics used as alternative fuels (1.A.2)

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Plastics	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	The equivalent assessment of the uncertainty in industrial waste plastics in "5.C Incineration" is used.	The uncertainty based on expert judgment in industrial waste statistics is applied.	Combined by using the formula for propagation of errors
	CH_4	-100%	+216%	-30%	+30%	-104%	+218%			
	N_2O	-44%	+44%	-30%	+30%	-53%	+53%			
Waste oil	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	The equivalent assessment of the uncertainty in industrial waste oil in "5.C Incineration" is used.		Combined by using the formula for propagation of errors
	CH_4	-100%	+181%	-30%	+30%	-104%	+184%			
	N_2O	-76%	+76%	-30%	+30%	-81%	+81%			
Wood	CH_4	-100%	+412%	-30%	+30%	-104%	+413%	The equivalent assessment of the uncertainty in industrial waste paper/cardboard or wood in "5.C Incineration" is used.		Combined by using the formula for propagation of errors
	N_2O	-64%	+64%	-30%	+30%	-71%	+71%			

- ***Time-series Consistency***

Data on the amount of waste oil and wood used as alternative fuels have been available since FY1998. For waste oil, consistent data over the time series are developed by using the total amount of waste oil incinerated without the use of waste oil as alternative fuel. For wood, the average of FY1998–2002 data is used to estimate the amount of wood for the past years. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Due to the re-examination of data sources for waste oil as alternative fuels, emission estimates were recalculated.
- Identifying the additional uses of biomass-based plastic products, emission estimates were recalculated.
- Updating the statistical data, emission estimates were recalculated. For detail, see the section "7.1.5. General Recalculations for Emissions from Waste Sector"
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.3.2.c. Waste Tires Used as Raw Materials and Alternative Fuels (1.A.1 and 1.A.2)

a) Category Description

This category includes the emissions from the use of waste tires as alternative fuels.

b) Methodological Issues

1) CO_2

- ***Estimation Method***

The emissions are calculated by multiplying the incinerated amount of waste tires used as raw materials or fuels by Japan's country-specific emission factor.

- ***Emission Factor***

The emission factor for waste tires is calculated by multiplying the fossil fuel-derived carbon content of the waste tires by the oxidation factor of the waste tires at the facilities that use waste tires as fuel. The volume of the fossil fuel-derived carbon in the waste tires is calculated by the material contents of new tires. The oxidation factor for waste tires is set to the default value of 100% indicated in the *2006 IPCC Guidelines*.

Calculation of emission factor for the incineration of waste tires (dry basis)
= (Fossil fuel-derived carbon content in waste tires)
× (Oxidation factor of waste tires)
× 1000 × 44 / 12

- ***Activity Data***

Activity data (dry basis) is calculated by subtracting the water content in the waste tires determined from analyses of three constituents of divided tires reported in *the Basic Waste Date Fact Book (2000)* published by Japan Environmental Sanitation Center from the amount of waste tires used as raw material or fuel (wet basis) in the *Tire Industry of Japan*, published by the Japan Automobile Tire Manufacturers Association, Inc.

2) CH_4, N_2O

- ***Estimation Method and Emission Factor***

See the section "7.4.3.2. Direct Use of Waste as Alternative Fuel (1.A.)"

- ***Activity Data***

The volume of waste tires used as raw material or fuel by usage that is determined during the calculation of the CO_2 emissions from this source is used. For the activity data, the volume of waste tires recorded in the following categories are used: "Cement kilns" for use in cement kilns; "Medium to small boilers", "Use by tire factories", "Use by paper manufacturers", and "Power generation" for use in boilers; "metal refining" for use in carbonization; and "Gasification" for use in gasification processes.

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment is conducted as well as assessment in the category of the industrial waste incineration. Details of the uncertainty assessment on this category are shown in the Table 7-64.

Table 7-64 Uncertainty assessment for waste tire used as alternative fuels (1.A.1 and 1.A.2)

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Waste tire	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in industrial waste plastic is substituted based on expert judgment.	The uncertainty based on expert judgment in industrial waste statistics is applied.	Combined by using the formula for propagation of errors
	CH_4	-100%	+216%	-30%	+30%	-104%	+218%			
	N_2O	-44%	+44%	-30%	+30%	-53%	+53%			

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculations are conducted.

f) Category-specific Planned Improvements

No improvements are planned.

7.4.3.3. Incineration of Waste Processed as Fuel (1.A.)

7.4.3.3.a. Incineration of Refuse-based Solid Fuels (RDF and RPF) (1.A.1 and 1.A.2)

a) Category Description

In this category, CO_2, CH_4, and N_2O emissions from waste that is processed and used as fuel are estimated and reported. Refuse-derived solid fuels (RDF as Refuse Derived Fuel and RPF as Refuse Paper and Plastic Fuel) are used for the estimation of emissions from fuels produced from waste. The reporting categories for the above emissions are included in “Energy industries (1.A.1.)” and “Manufacturing industries and construction (1.A.2)” as indicated in Table 7-24 The fuel types are classified as “Other fossil fuels” and/or “Biomass” as indicated in Table 7-23.

b) Methodological Issues

1) CO_2

- ***Estimation Method***

Emissions are estimated by multiplying the amount of RDF and RPF incinerated by Japan’s country-specific emission factor.

$$E_{RDF} = EF_{RDF} \times AD_{RDF}$$

E_{RDF} : CO_2 Emissions from RDF use [kg-CO_2]
EF_{RDF} : Emission factor for RDF use (dry basis) [kg-CO_2/t]
AD_{RDF} : Activity data for RDF use (dry basis) [t]

$$E_{RPF} = E_{RPF} \times AD_{RPF}$$

E_{RPF} : CO_2 Emissions from RPF use [kg-CO_2]
EF_{RPF} : Emission factor for RPF use (dry basis) [kg-CO_2/t]
AD_{RPF} : Activity data for RPF use (dry basis) [t]

- ***Emission Factor***

Emission factor associated with the use of the refuse-derived solid fuels (RDF and RPF) is calculated for RDF and RPF respectively by the equation shown below.

➢ ***RDF***

Emission factor for RDF use is estimated by multiplying the fraction of plastic-derived content contained in RDF (dry basis) by the fraction of carbon content contained in plastic by, the combustion rate of RDF at RDF combustion facilities by fossil-fuel derived fraction of plastic in RDF.

$$EF_{RDF} = 1000 \times P_{RDF} \times C \times OF_{RDF} / 12 \times 14 \times FPF_{RDF}$$

$$= 1000 \times 0.296 \times 0.751 \times 1.0 / 12 \times 44$$

$$= 816 \text{ [kg-}CO_2\text{/t]} \times FPF_{RDF}$$

P_{RDF} : Fraction of plastic-derived content contained in RDF (dry basis)
C : Fraction of carbon content contained in plastic (dry basis)
OF_{RDF} : Oxidation factor of RDF at RDF combustion facilities
FPF_{RDF} : Fossil-fuel derived fraction of plastic in RDF

- ***Fraction of Plastic-derived Content Contained in RDF (Dry basis)(P_{RDF})***

Fraction of plastic-derived content contained in RDF in dry basis is converted from that in wet basis. Fraction of plastic-derived content contained in RDF in wet basis (24.7%) is estimated based on the *Proper Management of Refuse-derived Fuels compiled by the Study Group for Proper Management of RDF*. It is converted into the value in dry basis with the fraction of water content of MSW (20%) applied in "7.2.1. Managed Disposal Sites (5.A.1.)" as well as "7.4.1.2. Industrial Waste (5.C.1.-), CO_2".

- ***Fraction of Carbon Content Contained in Plastic (Dry basis)(C)***

Due to the fact that most of plastic contained in RDF is considered to be municipal solid waste-derived, the average fraction of carbon content used in "7.4.1.1. Municipal Solid Waste (5.C.1.-)" as shown in Table 7-27 is applied for the fraction of carbon content contained in plastic (dry basis).

- ***Oxidation factor for RDF at RDF Combustion Facilities (OF_{RDF})***

As applied in "7.4.1.1. Municipal Solid Waste (5.C.1.-), CO_2", the default value provided in the *2006 IPCC Guidelines* (100%) is also applied for the oxidation factor for RDF at RDF combustion facilities.

- ***Fossil-fuel derived fraction of plastic in RDF (FPF_{RDF})***

Due to the fact that most of plastic contained in RDF is considered to be municipal solid waste-derived, the same values in "7.4.1.1. Municipal Solid Waste (5.C.1.-)" are applied. Note it is

assumed that plastic in RDF consist of similar composition (plastic bottles/plastics other than plastic bottles) in municipal solid waste plastics incinerated.

- ***RPF***

Because the quality of RPF is categorized into "coal-equivalent product" and "coke-equivalent product"(see Reference #55), emission factor for RPF is established for each quality of product. However, in the case that the amount of use of each quality of product for estimating activity data is unavailable, emission factor is established by the weighted average of each emission factor for coal-equivalent product and coke-equivalent product with the average fraction of amount of use of each product (see "*Emission Factor for the Use of RPF (Weighted Average) (Dry basis)*" as described herein below.)

Coal-equivalent product

$$EF_{RPF,coal} = 1000 \times P_{RPF,\,coal} \times C \times OF_{RPF} / 12 \times 44 \times FPF_{RPF}$$

$$= 1000 \times 0.528 \times 0.737 \times 1.0 / 12 \times 44 \times FPF_{RPF}$$

$$= 1426\ [\text{kg-}CO_2/\text{t}] \times FPF_{RPF}$$

Coke-equivalent product

$$EF_{RPF,coke} = 1000 \times P_{RPF,coke} \times C \times OF_{RPF} / 12 \times 44 \times FPF_{RPF}$$

$$= 1000 \times 0.910 \times 0.737 \times 1.0 / 12 \times 44 \times FPF_{RPF}$$

$$= 2457\ [\text{kg-}CO_2/\text{t}] \times FPF_{RPF}$$

$EF_{RPF,coal}$: Emission factor for the use of coal-equivalent product RPF (dry basis) [kg-CO_2/t]
$EF_{RPF,coke}$: Emission factor for the use of coke-equivalent product RPF (dry basis) [kg-CO_2/t]
$P_{RPF,coal}$: Fraction of plastic-derived content contained in coal-equivalent product RPF (dry basis)
$P_{RPF,coke}$: Fraction of plastic-derived content contained in coke-equivalent product RPF (dry basis)
C : Fraction of carbon content contained in plastic (dry basis)
OF_{RPF} : Oxidation factor of RPF at RPF combustion facilities
FPF_{RDF} : Fossil-fuel derived fraction of plastic in RPF

- ***Fraction of Waste Plastic-derived Content Contained in RPF (Dry basis)($P_{RPF,coal/coke}$)***

The fraction of waste plastic-derived content contained in RPF in wet basis is established at 50% for coal-equivalent product and at 90% for coke-equivalent product based on the results of fact-finding survey conducted by the Japan RPF Industry Association.

The fraction of waste plastic-derived content contained in RPF in dry basis is calculated with the fraction of water content of RDF, to which the average water content of industrial waste plastics used for RPF production is applied; it is established at 5% based on expert judgment.

- ***Fraction of Carbon Content Contained in Plastic (Dry basis) (C)***

Due to the fact that most of plastic contained in RDF is industrial waste-derive (see Reference #70), the fraction of carbon content contained in plastic in dry basis (73.7%) is calculated by using the fraction of carbon content contained in industrial waste plastic applied in "7.4.1.2. Industrial Waste (5.C.1.-), CO_2" (70%) and the fraction of water content of industrial waste plastic (5%).

- ***Oxidation factor for RPF at RPF Fuel Facilities (OF_{RPF})***

  As applied in "7.4.1.2. Industrial Waste (5.C.1.-)", the value provided in the *2006 IPCC Guidelines* (100%) is also applied for the oxidation factor for RPF at RPF combustion facilities.

- ***Fossil-fuel derived fraction of plastic in RPF***

  The same values for industrial waste plastic are applied (See Table 7-33).

- ***Emission Factor for RPF Use (Weighted Average) ($EF_{RPF,av}$) (Dry basis)***

  In the case that the amount of use of coal-equivalent product RPF and coke-equivalent product RPF for estimating activity data is unavailable, emission factor is determined by the weighted average of each emission factor for coal-equivalent product and coke-equivalent product with the average fraction of the amount of use of each product.

  Production percentage of RPF of coal-equivalent product and coke-equivalent product (wet basis) is obtained from the survey results conducted by Japan RPF Industry Association and is converted into the value in dry basis. The fraction of water content of RPF is established at 3% for coal-equivalent product and at 1% for coke-equivalent product based on the RPF quality standards provided by the Japan RPF Industry Association. The estimated fractions of production percentage in dry basis are applied to all the reporting years because relevant statistics is unavailable.

$$EF_{RPF,av} = EF_{RPF,coal} \times P_{coal} + EF_{RPF,coke} \times P_{coke}$$

$$= (1419 \times FPF_{RPF}) \times 0.797 + (2445 \times FPF_{RPF}) \times 0.203$$

$$= 1636\ [\text{kg-}CO_2/\text{t}] \times FPF_{RPF}$$

$EF_{RPF,av}$: Emission factor for RPF use (Weighted Average) (dry basis) [kg-CO_2/t]
P_{coal} : Fraction of the use of coal-equivalent product RPF (dry basis)
P_{coke} : Fraction of the use of coke-equivalent product RPF (dry basis)

Table 7-65 CO_2 emission factors for the emissions from the use of refused-derived fuel (RDF)or refuse paper & plastic fuel (RPF)

Item	Emission Factor [kg-CO_2/t (dry)]
RDF	816
RPF (coal-equivalent products)	1,426
RPF (coke-equivalent products)	2,457
RPF (weighted average values)	1,636

Note: Each emission factor indicated in the table are applied 100% of fossil-fuel derived fraction (*FPF*) .

- ***Activity Data***

➢ ***RDF***

The amount of RDF production is used as the substitute for the amount of use of RDF. Activity data (dry basis) is calculated by subtracting the water content of RDF from the amount of RDF production at RDF production facilities (wet basis) provided by the *Report on Survey of State of Treatment of Municipal Solid Waste*. For the fiscal years that the data are unavailable, emission estimates are conducted substituting the values of the refuse processing capacity.

$$A_{RDF} = a_{RDF} \times SC_{RDF}$$

A_{RDF} : Activity data for RDF use (dry basis)
a_{RDF} : Amount for RDF production at RDF production facilities (wet basis) [t]

SC_{RDF} : Fraction of dry matter content of RDF (estimated by (1 – fraction of water content of RDF))

➢ ***RPF***

The amounts of RPF used in chemical industry, paper industry, cement manufacturer, and petroleum product manufacturer are estimated. The amount of RPF (dry basis) for paper industry is obtained from the survey results conducted by the Japan Paper Association. The amounts of RPF (dry basis) for chemical industry, cement manufacturer, and petroleum product manufacturer are obtained by using the average water content of RPF and also the survey results (wet basis) conducted by the Japan Cement Association and the Japan Automobile Manufacturers Association. All of the plastic included in RPF are considered to be fossil-fuel derived.

Table 7-66 Amount of use of refuse-derived fuel (RDF) or refuse paper & plastic fuel (RPF) (wet basis)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
RDF	kt (dry)	32	37	140	392	373	375	365	355	359	368	363	365	367
RPF	kt (dry)	NO	8	32	478	647	754	751	778	765	803	837	886	866

2) CH_4, N_2O

● ***Estimation Method and Emission Factor***

For the estimation method and the emission factors used, see "7.4.3.2. Direct Use of Waste as Alternative Fuel (1.A.)".

Table 7-67 Data used for the calculation of the methane and nitrous oxide emission factors for wastes used as raw material and fuel

Item		Emission factor for furnaces and ovens (Energy sector)	Calorific value
RDF	Boilers	CH_4: Boilers (Steam coal, coke, other solid fuels) N_2O: Boilers (other than fluidized-bed) (solid fuel)	Calorific value of RDF
RPF	Cement kilns, boilers	Other industrial furnaces (solid fuel)	Calorific value of RPF*
	Boilers	CH_4: Boilers (Steam coal, coke, other solid fuels) N_2O: Boilers (other than fluidized-bed) (solid fuel)	

Note: *Weighted average of calorific values calculated based on the manufacturing ratio of Coal substitution RPF and Coke substitution RPF given by the Japan RPF Industry Association

● ***Activity Data***

➢ ***RDF***

The entire amount of RDF production (wet basis) used for CO_2 emission estimates is also used for the amount of use of RDF for boiler.

➢ ***RPF***

Out of the amount of RPF used for CO_2 emission estimates, the amounts of RPF used in chemical industry, paper industry, and petroleum products manufacturer are applied to the amount of PRF used for boiler (wet basis). The amount of PRF used in cement industry is applied to the amount of RPF used for cement kiln (wet basis). Because the amount of RPF used in paper industry is on a dry basis, the average water content of RPF is added to obtain the value on a wet basis.

➢ ***Activity Data Converted into Energy Units (Reference Value)***

Activity data converted into energy units to be reported in CRF is calculated as indicated below.

Activity data converted into energy units

= (Amount of RDF & RPF consumed [kg (wet)])
×calorific value of corresponding fuel [MJ/kg])/ 10^6

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment is conducted as well as the assessment for the municipal waste or industrial waste incineration. Details of the uncertainty assessment on this category are indicated in the Table 7-68.

Table 7-68 Uncertainty assessment for incineration of waste refuse-based solid fuels (1.A.1 and 1.A.2)

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
RDF	CO_2	-2%	+2%	-10%	+10%	-10%	+10%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in municipal waste plastics is substituted based on expert judgment.	The uncertainty in municipal waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	CH_4	-39%	+39%	-10%	+10%	-40%	+40%			
	N_2O	-34%	+34%	-10%	+10%	-35%	+35%			
RPF	CO_2	-2%	+2%	-30%	+30%	-30%	+30%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in municipal waste plastics is substituted based on expert judgment.	The uncertainty based on expert judgment in industrial waste statistics is applied.	Combined by using the formula for propagation of errors
	CH_4	-100%	+216%	-30%	+30%	-104%	+218%			
	N_2O	-44%	+44%	-30%	+30%	-53%	+53%			

- ***Time-series Consistency***

Since data on the amount of RDF produced are not available for the years prior to FY1997, these data are estimated by using the trend on capacity of refuse-based fuel-producing facilities. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

- Updating the statistical data including emission estimates for FY2009, 2011 and FY2012 were recalculated.
- Identifying the additional uses of biomass-based plastic products, emission estimates were recalculated.
- See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.5. Wastewater Treatment and Discharge (5.D.)

The CH_4 and N_2O emissions from wastewater handling are estimated in the “Wastewater Treatment and Discharge (5.D.)”. The target categories are shown in Table 7-69. Since an emission factor that takes into account emissions from wastewater and sludge treatment processes is used in Japan, emissions from these processes are reported altogether.

Table 7-69 Categories overview for wastewater treatment and discharge (5.D.)

Category	Wastewater type		Treatment type			CH_4	N_2O
5.D.1. (7.5.1)	Domestic wastewater	Sewage from public sewer system	Sewage treatment plants (7.5.1.1)	Standard activated sludge process		○	○
				Anaerobic-aerobic activated sludge process			○
				Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process			○
				Recycled nitrification-denitrification membrane bioreactor			○
		Domestic waste water and human waste	Domestic wastewater treatment facilities (mainly septic tanks) (7.5.1.2)	Community plant		○	○
				Gappei-shori johkasou		○	○
		Human waste		*Tandoku-shori johkasou*		○	○
				Vault toilet		○	○
		Human waste and septic tank sludge from domestic wastewater treatment facilities	Human waste treatment facilities (7.5.1.3)	High-load denitrification treatment		○	○
				Membrane separation		○	○
				Anaerobic treatment		○	○
				Aerobic treatment		○	
				Standard denitrification treatment		○	
				Other		○	
		Untreated domestic wastewater	Natural decomposition of domestic wastewater (7.5.1.4)	Discharge of untreated domestic wastewater	From *Tandoku-shori johkasou*	○	○
					From Vault toilet	○	○
					From On-site treatment	○	○
		Human waste and septic tank sludge		Sludge disposal at sea[1)]		○	○
		Sewage sludge				○	○
5.D.2. (7.5.2)	Industrial wastewater		Industrial wastewater treatment (7.5.2.1) (Sewage treatment plants)			○	○
	Landfill leachate		Landfill leachate treatment (7.5.2.2)			○	○

Note:
1) Due to legal regulations on sludge disposal at sea, there has been no activity since FY2009.

Estimated greenhouse gas emissions from wastewater handling are shown in Table 7-70. In FY2014, emissions from this source category are 2,810 kt-CO_2 eq. and accounted for 0.2% of the national total emissions (excluding LULUCF). The emissions from this source category decreased by 30.9% compared to those in FY1990. This emission decrease is the result of decrease in the amount of CH_4 emissions from "Degradation of Domestic Wastewater in Nature" because the practice of wastewater treatment at wastewater treatment plants increased in Japan. Due to the same reason, the N_2O emissions from the subcategory of "Sewage Treatment Plants (5.D.1.-)" for FY1995 through FY1998 increased.

Table 7-70 GHG emissions from wastewater treatment and discharge (5.D.)

Gas	Category		Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CH_4	5.D.1. Domestic wastewater	Sewage treatment plant	kt-CH_4	8.6	9.9	11.1	12.1	12.4	12.0	12.4	12.7	12.7	12.7	12.1	12.5	12.5
		Domestic wastewater facilities	kt-CH_4	33.8	35.0	38.8	32.8	33.1	33.7	33.2	32.7	32.9	32.9	32.9	32.8	32.7
		Human waste treatment plant	kt-CH_4	5.2	3.2	1.8	1.0	0.9	0.8	0.7	0.7	0.6	0.5	0.5	0.5	0.5
		Decomposition of untreated wastewater discharged	kt-CH_4	60.2	50.8	39.5	28.7	26.8	24.7	23.9	22.4	21.1	20.0	19.3	18.1	17.2
	5.D.2. Industrial wastewater	Industrial wastewater treatment	kt-CH_4	5.2	5.1	5.0	4.9	4.9	4.9	4.9	4.7	4.6	4.5	4.3	4.3	4.3
		Landfill leachate treatment	kt-CH_4	1.2	1.2	1.1	0.8	0.7	0.7	0.6	0.4	0.4	0.3	0.3	0.3	0.3
	Total		kt-CH_4	114.4	105.1	97.3	80.2	78.7	76.7	75.8	73.6	72.2	70.9	69.5	68.6	67.5
			kt-CO_2 eq.	2,860	2,628	2,432	2,006	1,967	1,919	1,895	1,839	1,806	1,772	1,738	1,714	1,687
N_2O	5.D.1. Domestic wastewater	Sewage treatment plant	kt-N_2O	1.39	1.55	1.58	1.67	1.74	1.67	1.69	1.70	1.67	1.67	1.55	1.59	1.59
		Domestic wastewater facilities	kt-N_2O	1.58	1.65	1.70	1.78	1.78	1.78	1.76	1.72	1.72	1.71	1.70	1.69	1.68
		Human waste treatment plant	kt-N_2O	0.22	0.26	0.12	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01
		Decomposition of untreated waste water discharged	kt-N_2O	0.44	0.35	0.27	0.19	0.18	0.16	0.16	0.15	0.14	0.13	0.13	0.12	0.11
	5.D.2. Industrial wastewater	Industrial wastewater treatment	kt-N_2O	0.39	0.38	0.33	0.39	0.38	0.39	0.41	0.39	0.38	0.38	0.37	0.37	0.37
		Landfill leachate treatment	kt-N_2O	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Total		kt-N_2O	4.05	4.21	4.01	4.08	4.11	4.04	4.04	3.99	3.94	3.91	3.78	3.79	3.77
			kt-CO_2 eq.	1,207	1,256	1,195	1,214	1,224	1,204	1,204	1,188	1,174	1,165	1,127	1,131	1,124
Total			kt-CO_2 eq.	4,067	3,884	3,627	3,220	3,191	3,122	3,099	3,027	2,980	2,937	2,865	2,845	2,810

7.5.1. Domestic Wastewater (5.D.1.)

Domestic and commercial wastewater generated in Japan is treated at various wastewater treatment facilities (e.g., sewage treatment plants, septic tanks, human-waste treatment plants) and greenhouse gas emissions from these sources are reported under “Domestic and Commercial Wastewater (5.D.1.)”. Because the CH_4 and N_2O emission characteristics differ from one wastewater treatment facility to another, a different emission estimation method is established for each facility.

The characteristics, effectiveness, and economic efficiency of wastewater treatment systems are thoroughly reviewed, and the most suitable systems are selected for each area in Japan with care also being taken to avoid excessive expenditure. As indicated in “Waste Treatment in Japan” (the Ministry of the Environment) public sewerage system is spreading from large cities to smaller municipalities and used by 73.1% of the population at the end of FY2014.

Domestic wastewater treatment systems (e.g. *gappei shori johkasou*) are being promoted as an effective means of supplementing sewerage systems in smaller municipalities with low population densities and little flat land. In FY2014, septic tanks (*johkasou*) are used by 20.6% of the population, with the remainder being treated after collection or on-site.

“NA” is reported on the CRF table for activity data instead of reporting the amount of organic carbon based on BOD values because the activity data for this source are estimated using a country-specific method by each gas and each wastewater treatment facility.

7.5.1.1. Sewage Treatment Plant (5.D.1.-)

a) Category Description

This category covers CH_4 and N_2O emissions from treatment of wastewater at sewage treatment plants.

b) Methodological Issues

- ***Estimation Method***

Emissions of CH_4 and N_2O from this source are calculated using Japan’s country-specific method in accordance with the decision tree of the *2006 IPCC Guidelines* (Page 6.10, Fig. 6.2). Emissions are

calculated by multiplying the volume of sewage treated at sewage treatment plants by the emission factor.

$$E = EF \times A$$

E : Amount of CH_4 or N_2O emitted from sewage treatment plants in conjunction with domestic/commercial wastewater treatment [kg-CH_4], [kg-N_2O]

EF : Emission factor [kg-CH_4/m^3], [kg-N_2O/m^3]

A : Yearly amount of sewage treated at a sewage treatment plant [m^3]

- ***Emission Factors***

1) CH_4

Emission factors are established by adding the simple averages for each treatment process, having taken the actual volume of CH_4 released from sludge treatment and water treatment processes measured at sewage treatment plants from research studies conducted in Japan (Refer to Reference #7).

$$EF_{CH4} = EF_{WWTT} + EF_{SSTT}$$
$$= 8.764 \times 10^{-4} \text{ [kg-}CH_4/m^3\text{]}$$

EF_{CH4} : CH_4 Emission factor
EF_{WWTT} : Average of emission factor for wastewater treatment processes (528.7 [mg-CH_4/m^3])
EF_{SSTT} : Average of emission factor for sludge treatment processes (348.0 [mg-CH_4/m^3])

2) N_2O

Emission factors are established on the basis of measured values of N_2O volume emitted from wastewater and sludge treatment processes at sewage treatment plants which is obtained from research studies conducted in the country. Since the research studies revealed that the amount of N_2O emission varies according to the type of wastewater treatment process at sewage treatment plants, the N_2O emission factor for each wastewater treatment type is developed based on the latest findings in the country (Reference #19).

$$EF_{N2O} = EF_{WWTTi} + EF_{SSTT}$$

EF_{N2O} : N_2O Emission factor
EF_{WWTTi} : Emission factor for wastewater treatment process *i* (Table 7-71)
EF_{SSTT} : Average of emission factor for sludge treatment process (0.6 [mg-N_2O/m^3])

Table 7-71 N_2O Emission factor by wastewater treatment process at sewage treatment plant

Wastewater treatment process	N_2O EF for wastewater treatment process [mg-N_2O/m^3]	N_2O EF for sludge treatment process [mg-N_2O/m^3]
Standard activated sludge process[1)]	142	0.6
Anaerobic-aerobic activated sludge process	29.2	0.6
Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process[2)]	11.7	0.6
Recycled nitrification-denitrification membrane bioreactor	0.5	0.6

Note:
1) Includes all the wastewater treatment processes other than indicated above.
2) Includes all the wastewater treatment processes which remove nitrogen the same level or greater than Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process, but excludes recycled nitrification-denitrification membrane bioreactor.

- ***Activity Data***

Activity data for N_2O emissions by wastewater treatment process at sewage treatment plants are provided by the Ministry of Land, Infrastructure, Transport and Tourism. Total amount of wastewater treated used for N_2O emission estimates are also used for the activity data for CH_4 emission estimates.

Table 7-72 Activity data for wastewater treated at sewage treatment plant

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Standard activated sludge process	10^6 m^3	9,761	10,780	10,686	11,405	11,937	11,429	11,508	11,552	11,358	11,288	10,485	10,736	10,736
Anaerobic-aerobic activated sludge process	10^6 m^3	73	446	1,523	1,039	485	809	809	868	909	909	953	931	931
Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process	10^6 m^3	23	89	487	1,374	1,676	1,483	1,858	2,049	2,181	2,308	2,355	2,629	2,629
Recycled nitrification-denitrification membrane bioreactor	10^6 m^3	NO	NO	NO	0.1	0.3	1	1	1	2	20	20	15	15
Total	10^6 m^3	9,857	11,316	12,696	13,818	14,098	13,722	14,176	14,470	14,450	14,525	13,813	14,311	14,311

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties in emission factors for CH_4 and N_2O in sewage treatment plant are evaluated by using the 95% confidence intervals of actual measurement data which are used for calculation of emission factors. As for the uncertainties in activity data, the uncertainties in sewage data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in Table 7-73.

Table 7-73 Uncertainty assessment for sewage treatment plant on the category “Domestic wastewater (5.D.1.-)”

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Sewage treatment plant	CH_4	-31%	+31%	-5%	+5%	-31%	+31%	The uncertainty is assessed by using the 95% interval confidence of actual measurement data in “FY2006, Review of Greenhouse Gases Emissions Estimation Methods, Vol. 4 waste sector”.	The uncertainty in sewage statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	N_2O	-100%	+146%	-5%	+5%	-100%	+146%			

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculations are conducted.

f) Category-specific Planned Improvements

No improvements are planned.

7.5.1.2. Domestic Sewage Treatment Plant (Mainly Septic Tanks) (5.D.1.-)

a) Category Description

A part of domestic and commercial wastewater not processed in the public sewerage in Japan is processed in community plants, *gappei-shori johkasou*, the *tandoku-shori johkasou*, and vaults. The *gappei-shori* and *tandoku-shori* are decentralized wastewater treatment facilities installed at an individual home.

Table 7-74 Type of sewage and sewage treatment

Sewage treatment type		Sewage type
Community plants	Small-scale wastewater treatment facility regionally established	Human waste and miscellaneous wastewater
Gappei-shori johkasou	Wastewater treatment unit installed at an individual household	Human waste and miscellaneous wastewater
Tandoku-shori johkasou	Wastewater treatment unit installed at an individual household	Human waste
Vaults	Installed at an individual household	Human waste

This category covers CH_4 and N_2O emissions from domestic sewage treatment plants. Emissions from human waste within its residence time in vault toilets are accounted for under this category, whereas the emissions that occur after the waste is collected from vault toilets are accounted for under "Human waste treatment facilities (5.D.1.-)".

b) Methodological Issues

- ***Estimation Method***

Emissions of CH_4 and N_2O from this source are calculated using Japan's country-specific method, in accordance with decision tree the *2006 IPCC Guidelines* (Page 6.10, Fig. 6.2). Emissions are calculated by multiplying the annual population of treatment for each type of domestic sewage treatment plant by the emission factor.

$$E = \sum_i \left(EF_i \times A_i \right)$$

E : Emissions of methane and nitrous oxide from the processing of domestic and commercial wastewater at domestic sewage treatment plants (i.e. household septic tanks) [kg-CH_4], [kg-N_2O]

EF_i : Emission factor for domestic sewage treatment plant i [kg-CH_4/person], [kg-N_2O/person]

A_i : Population (persons) requiring waste processing at domestic sewage treatment plant i per year

- ***Emission Factors***

CH_4 and N_2O emission factors for this source are determined as described below:

➢ ***Community Plants***

- ***CH_4***

- For the CH_4 emission factor for community plants by FY1995, the values indicated in Tanaka (1998) are used.
- For the values from FY2005 onwards, the values indicated in Ike and Souda (2010) are used taking into account the performance improvement in the plants.
- The values for FY1996 through FY2004 are interpolated.

- ***N_2O***
  - For the N_2O emission factor for community plants by FY1995, the mean values of the upper limit and the lower limit of actual measured values indicated in Tanaka (1997) are used.
  - For the values from FY2005 onwards, the values indicated in Ike and Souda (2010) are used taking into account the performance improvement of the plants.
  - The values for FY1996 through FY2004 are interpolated.

Table 7-75 CH_4 and N_2O Emission factors for community plants

Gas	Unit	FY1990-1995	FY1996-2004	From FY2005
CH_4	kg-CH_4 /person-year	0.195	Calculated by interpolation with the values of FY1995 and FY2005	0.062
N_2O	kg-N_2O-N/ person-year	0.0394	Calculated by interpolation with the values of FY1995 and FY2005	0.0048

➢ ***Gappei-shori Johkasou***

- ***CH_4 and N_2O***

On the basis of FY2011, Survey and Studies for the Development of Emission Factor for the Preparation for the National Greenhouse Gas Inventory (Reference #20) and FY2012, Survey and Studies for the Development of Emission Factor for the Decentralized Commercial Wastewater Treatment for the National Greenhouse Gas Inventory, the Ministry of the Environment (Reference #21), emission factors are established for two different periods; before and after FY2001 where the Building Standards Act were revised.

- For the period FY1990-2001, the emission factor for *national structure standards-compatible johkasou* is used.
- For the period from FY2002 and onward, the average emission factor for *national structure standards-compatible johkasou* and *performance certified johkasou* (BOD removal type and BOD and nitrogen removal type) is used due to the fact that the technical guidelines for *johkasou* of the Building Standards Act were revised in FY2001, and the installation of *performance certified johkasou* was started.

Table 7-76 CH_4 and N_2O Emission factors for *gappei-shori johkasou*

Gas	Unit	FY1990-2001	From FY2002
CH_4	kg-CH_4/ person-year	2.477	1.835
N_2O	kg-N_2O/ person-year	0.0717	0.00831

➢ ***Tandoku-shori Johkasou***

- ***CH_4 and N_2O***

Emission factors are obtained from Reference #20 and Reference #21. The same emission factor is applied for all the reporting years because there is no significant technological advancement in *tandoku-shori johkasou* in previous years.

Table 7-77 CH_4 and N_2O Emission factors for *tandoku-shori johkasou*

Gas	Unit	From FY1990
CH_4	kg-CH_4/ person-year	0.46
N_2O	kg-N_2O/ person-year	0.039

➢ ***Vault Toilets***

- ***CH_4 and N_2O***

Emission factors are obtained from Reference #20 and Reference #21. The same emission factor is used for all the reporting years because there is no significant technological advancement in vault toilets in previous years.

Table 7-78 CH_4 and N_2O Emission factors for vault toilets

Gas	Unit	From FY1990
CH_4	kg-CH_4/ person-year	0.062
N_2O	kg-N_2O/ person-year	0.000022

● ***Activity Data***

Annual treatment population by type of domestic sewage treatment plant for community plants, *gappei-shori johkasou, tandoku-shori johkasou,* and vault toilets given in the *Waste Treatment in Japan* is used as the activity data for CH_4 and N_2O emitted in association with domestic wastewater treatment facilities.

Table 7-79 Annual treatment population by type of domestic sewage treatment plant (1,000 persons)

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Community plant	1000 person	493	398	414	552	361	336	416	297	293	286	289	304	302
Gappei-shori johkasou	1000 person	7,983	8,515	10,806	12,792	13,286	13,939	13,854	13,792	14,082	14,276	14,341	14,492	14,563
Tandoku-shori johkasou	1000 person	25,119	26,105	23,289	18,303	17,187	15,924	15,413	14,712	13,948	13,316	13,052	12,383	11,818
Vault toilet	1000 person	38,920	29,409	20,358	13,920	12,983	12,121	11,301	10,671	9,984	9,348	8,849	8,242	7,725
Total	1000 person	72,515	64,427	54,867	45,567	43,817	42,320	40,984	39,472	38,307	37,226	36,531	35,421	34,408

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties in emission factors for CH_4 and N_2O in *gappei-shori johkasou, tandoku-shori johkasou,* and vault toilet are evaluated by using the 95% confidence intervals of actual measurement data which are used for calculation of emission factors. As for the uncertainties in emission factors for CH_4 and N_2O in community plant, the uncertainties in similar emission sources are substituted. As for the uncertainties in activity data, the uncertainties in domestic wastewater data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-80.

Table 7-80 Uncertainty assessment for domestic sewage treatment plant on the category "Domestic wastewater (5.D.1.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Community Plant	CH_4	-32%	+32%	-10%	+10%	-33%	+33%	The uncertainty is assessed based on expert judgment. (The uncertainty in Gappei-shori johkasou is substituted).	The uncertainty in municipal waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	N_2O	-45%	+45%	-10%	+10%	-46%	+46%			
Gappei-shori johkasou	CH_4	-32%	+32%	-10%	+10%	-33%	+33%	Quoted from "Report in FY2012, Survey and Studies for the Development of Emission Factor for the Decentralized Commercial Wastewater Treatment for the National Greenhouse Gas Inventory"		Combined by using the formula for propagation of errors
	N_2O	-45%	+45%	-10%	+10%	-46%	+46%			
Tandoku-shori johkasou	CH_4	-84%	+84%	-10%	+10%	-84%	+84%			Combined by using the formula for propagation of errors
	N_2O	-87%	+87%	-10%	+10%	-88%	+88%			
Vault toilets	CH_4	-49%	+49%	-10%	+10%	-50%	+50%			Combined by using the formula for propagation of errors
	N_2O	-72%	+72%	-10%	+10%	-73%	+73%			

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculations are conducted.

f) Category-specific Planned Improvements

No improvements are planned.

7.5.1.3. Human-Waste Treatment Plant (5.D.1.-)

a) Category Description

This category covers emissions of CH_4 and N_2O emissions from treatment of vault toilet human waste and septic tank sludge collected at human waste treatment plants.

b) Methodological Issues

1) CH4

- ***Estimation Method***

Emissions of CH_4 from this source are calculated using Japan's country-specific methodology in accordance with decision tree of the *2006 IPCC Guidelines* (Page 6.10, Fig. 6.2). Emissions are calculated by multiplying the volume of domestic wastewater treated at human waste treatment plants by the emission factor.

$$E = \sum_i \left(EF_i \times A_i \right)$$

E : Emission of methane from the processing of domestic and commercial wastewater at human waste treatment plants [kg-CH_4]

EF_i : Emission factor for human waste treatment plants (for treatment process i) [kg-CH_4/m^3]

A_i : Input volume of human waste and septic tank sludge at human waste treatment plants (for treatment process i) [m^3]

- ***Emission Factors***

Emission factors for CH_4 are determined by treatment processes type, including anaerobic, aerobic, standard denitrification and high-load denitrification treatments as well as membrane separation systems, for each of the human waste treatment plants (Refer to Reference #7).

Table 7-81 CH_4 emission factors by each treatment process

Treatment method	CH_4 Emission factor [kg-CH_4/m^3]	Data source
Anaerobic treatment	0.543	Estimated by multiplying the actual methane emissions given in Reference #41 by the value of 1 – CH_4 recovery rate (90%).
Aerobic treatment	0.00545	Simple average value of standard de-nitrification and high-load de-nitrification since actual data on emissions is not available.
Standard de-nitrification treatment	0.0059	Reference #75
High load de-nitrification treatment	0.005	Reference #75
Membrane separation	0.00545	Because the current status of its emissions is not identified, substituted the emission factor for aerobic treatment.
Other	0.00545	Because the current status of its emissions is not identified, substituted the emission factor for aerobic treatment.

- ***Activity Data***

Activity data for CH_4 emissions associated with the processing of wastewater at human waste treatment plants is determined from the calculated throughput volume for each of the treatment processes (Table 7-84), by multiplying the total volume of human waste and septic tank sludge processed at human waste treatment plants that are indicated in *Waste Treatment in Japan* (Table 7-82) by the capacity of each treatment process (Table 7-83).

Activity data for human waste treatment method i

= (Total amount of human waste and septic tank sludge by treatment method i)

× (Capacity of waste treatment method i) / (Total capacity of all waste treatment methods)

Table 7-82 Volume of human waste and septic tank sludge treated at their treatment plants

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Human waste from vault toilet	1000 kl/year	20,406	18,049	14,673	10,400	9,864	9,261	8,894	8,353	7,917	7,365	7,018	6,771	6,375
Septic tank sludge	1000 kl/year	9,224	11,545	13,234	13,790	14,089	13,987	14,064	13,989	13,760	13,547	13,519	13,726	13,562
Total	1000 kl/year	29,630	29,594	27,907	24,190	23,953	23,248	22,958	22,342	21,677	20,912	20,537	20,497	19,937

Table 7-83 Trends in treatment capacity by treatment process

Unit	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Anaerobic treatment	kl/day	34,580	19,869	10,996	6,476	5,856	4,801	4,444	4,144	3,891	3,265	3,159	3,059	2,779
Aerobic treatment	kl/day	26,654	19,716	12,166	8,465	8,005	7,892	7,535	6,961	6,753	6,200	6,469	6,001	5,899
Standard denitrification	kl/day	25,196	30,157	31,908	29,655	28,363	28,102	27,737	27,748	26,173	25,694	25,608	25,153	24,663
High-intensity denitrification	kl/day	8,158	13,817	16,498	17,493	15,980	15,784	14,938	16,285	16,104	15,778	15,030	14,529	14,336
Membrane separation	kl/day	NO	1,616	2,375	3,055	4,264	3,861	3,650	3,573	3,684	3,684	4,062	4,074	2,204
Other	kl/day	13,777	20,028	25,917	30,277	34,733	33,115	35,441	34,654	34,577	34,622	33,556	33,975	35,113

Table 7-84 Activity Data for human waste by treatment types

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Anaerobic treatment	1000 kl/year	9,455	5,589	3,073	1,642	1,443	1,193	1,088	992	925	765	738	722	652
Aerobic treatment	1000 kl/year	7,288	5,546	3,400	2,146	1,973	1,961	1,845	1,666	1,605	1,453	1,512	1,417	1,384
Standard denitrification	1000 kl/year	6,889	8,483	8,917	7,518	6,989	6,983	6,793	6,640	6,222	6,021	5,984	5,940	5,785
High-intensity denitrification	1000 kl/year	2,231	3,887	4,611	4,435	3,938	3,922	3,658	3,897	3,828	3,697	3,512	3,431	3,363
Membrane separation	1000 kl/year	NO	455	664	774	1,051	959	894	855	876	863	949	962	517
Other	1000 kl/year	3,767	5,634	7,243	7,676	8,559	8,229	8,679	8,293	8,220	8,113	7,841	8,024	8,236
Total	1000 kl/year	29,630	29,594	27,907	24,190	23,953	23,248	22,958	22,342	21,677	20,912	20,537	20,497	19,937

2) N_2O

- ***Estimation Method***

Emissions of N_2O from this source are calculated using Japan's country-specific methodology, in accordance with decision tree of the *2006 IPCC Guidelines* (Page 6.10, Fig. 6.2). Emissions are calculated by multiplying the volume of nitrogen treated at human waste treatment plants, by the emission factor.

$$E = \sum_i \left(EF_i \times A_i \right)$$

E : Emission of nitrous oxide from the processing of domestic and commercial wastewater at human was treatment plants [kg-N_2O]

EF_i : Emission factor for human waste treatment plants (by treatment process i) [kg-N_2O/kg-N]

A_i : Amount of nitrous oxide in human waste and septic tank sludge input at human waste treatment plants (treatment process i) [kg-N]

- ***Emission Factors***

The emission factors for N_2O are determined for each treatment process including high-load denitrification treatment and membrane separation systems using the results of actual case studies in Japan (Refer to Reference #7).

According to the survey study on the emission factors for human waste treatment facilities conducted in FY1994 (Tanaka et al., 1997) and FY2003 (Ohmura et al., 2004) in Japan, because of the advancement of the structure of human waste treatment facilities and the technology of operation and maintenance, actual measurement results show the improvement in the emission factors for high load de-nitrification treatment and membrane separation; therefore, different emission factors are used for FY1994 or before and from FY2003 onwards.

Table 7-85 Nitrous oxide emission factors by each treatment process

Treatment method	N_2O emission factors [kg-N_2O-N/kg-N]		
	FY1990-1994	FY1995-2002	From FY2003
High load de-nitrification treatment	0.033 [1)]	Calculated by interpolation using the values of FY1994 and FY2003	0.0029 [2)]
Membrane separation	0.033 [1)]	Calculated by interpolation using the values of FY1994 and FY2003	0.0024 [2)]
Other (including anaerobic treatment, aerobic treatment, standard de-nitrification treatment)	0.0000045[3)]		

Note:
1) Use median value of actual measurements at 13 plants given in Reference #76
2) Use median value of actual measurements at 13 plants given in Reference #68
3) Referred to Reference #75 (Calculated by dividing upper limit value for standard de-nitrification treatment (1.0×10^{-5} kg-N_2O/m^3) by treated nitrogen concentration in FY1994 (2,211 mg/l)).

- ***Activity Data***

The volume of nitrogen treated at human waste treatment plants is calculated by multiplying treated nitrogen concentration by the volume of human waste treated at these facilities (the sum of collected human waste and sewage in sewerage tank), given in the *Waste Treatment in Japan*. The treated nitrogen concentration is based on weighted average of the volume of nitrogen contained in collected human waste and sewage in sewerage tank derived using the volume of collected human waste and sewage in sewerage tank treated at human waste treatment plants.

Activity data
= [(Input volume of human waste at human waste treatment plants)
× (Nitrogen concentration in human waste)
+ (Input volume of septic tank sludge at human waste treatment plants)
× (Nitrogen concentration in septic tank sludge)]
× (percentage throughput of treatment process *i*)

- ***Input Volume of Human Waste and Septic Tank sludge at Human Waste Treatment Plants:***

See the data used for the calculation of CH_4 emissions from human waste treatment plants (Table 7-82).

- ***Percentage Throughput of the Human Waste Treatment Processes:***

See the data used for the calculation of CH_4 emission from human waste treatment plants (Table 7-83).

- ***Nitrogen Concentration in Human Waste and Septic Tank Sludge Input at Treatment Plants:***

For the nitrogen concentration in human waste and septic tank sludge input at treatment plants, the values analyzed for the period FY1989 - FY1991, FY1992 - FY1994, FY1995 – FY1997, and FY1998 - FY2000, respectively, are used based on the research conducted by Okazaki (2001). The value of FY2000 is substituted for the values from FY2001 onward. (See Table 7-86).

Table 7-86 Concentration of nitrogen contained in collected human waste and septic tank sludge

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Human waste from vault toilet	mg-N/l	3,940	3,100	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700	2,700
Septic tank sludge	mg-N/l	1,060	300	580	580	580	580	580	580	580	580	580	580	580
Weighted average	mg-N/l	3,043	2,008	1,695	1,491	1,453	1,425	1,401	1,373	1,354	1,327	1,304	1,280	1,258

Table 7-87 Activity data: Amount of nitrogen in human waste and septic tank sludge processed at human waste treatment plants

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Anaerobic treatment	kt-N	28.8	11.2	5.2	2.4	2.1	1.7	1.5	1.4	1.3	1.0	1.0	0.9	0.8
Aerobic treatment	kt-N	22.2	11.1	5.8	3.2	2.9	2.8	2.6	2.3	2.2	1.9	2.0	1.8	1.7
Standard denitrification	kt-N	21.0	17.0	15.1	11.2	10.2	9.9	9.5	9.1	8.4	8.0	7.8	7.6	7.3
High-intensity denitrification	kt-N	6.8	7.8	7.8	6.6	5.7	5.6	5.1	5.3	5.2	4.9	4.6	4.4	4.2
Membrane separation	kt-N	NO	0.9	1.1	1.2	1.5	1.4	1.3	1.2	1.2	1.1	1.2	1.2	0.7
Other	kt-N	11.5	11.3	12.3	11.4	12.4	11.7	12.2	11.4	11.1	10.8	10.2	10.3	10.4
Total	kt-N	90.2	59.4	47.3	36.1	34.8	33.1	32.2	30.7	29.4	27.7	26.8	26.2	25.1

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for the uncertainties in emission factors for CH4 and N2O in human waste treatment plant, the uncertainties in similar emission sources are substituted. As for the uncertainties in activity data, the uncertainties in domestic wastewater data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-88.

Table 7-88 Uncertainty assessment for human waste treatment plant on the category “Domestic wastewater (5.D.1.-)”

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Human waste treatment plants	CH_4	-84%	+84%	-10%	+10%	-84%	+84%	The uncertainty is assessed based on expert judgment. (The uncertainty in Tandoku-shori johkasou is substituted).	The uncertainty in municipal waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	N_2O	-87%	+87%	-10%	+10%	-88%	+88%			

- ***Time-series Consistency***

For N_2O emission factor, consistent data over the time series are constructed based on the actual measurement data by using the methods described in Table 7-85. For other parameters, data are constructed consistently for the entire time series. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculations are conducted.

f) Category-specific Planned Improvements

No improvements are planned.

7.5.1.4. Natural Decomposition of Domestic Wastewater (5.D.1.-)

a) Category Description

Although most of the domestic wastewater generated by Japanese households is processed at wastewater treatment plants, some is discharged untreated into public waters. The amounts of CH_4 and N_2O decomposes and emitted from this source are reported under this category.

b) Methodological Issues

- ***Estimation Method***

Estimation method is established in accordance with the method described in the *2006 IPCC Guidelines*. In the natural decomposition of wastewater, both the volume of organic matter extracted as sludge and recovered CH_4 are zero. Accordingly, CH_4 emissions are calculated by multiplying the volume of organic matter contained in the untreated domestic wastewater that is discharged into public waters by the emission factor. The N_2O emission is calculated by multiplying the volume of nitrogen contained in the wastewater by the emission factor.

$$E = EF \times A$$

E : Emission of methane or nitrous oxide from the natural decomposition of domestic wastewater [kg-CH_4], [kg-N_2O]

EF : Emission factor [kg-CH_4/kg-BOD], [kg-N_2O/kg-N]

A : Volume of organic matter [kg-BOD] or nitrogen [kg-N] in domestic wastewater

- ***Emission Factors***

Emission factors are determined in accordance with the *2006 IPCC Guidelines*. The emission factor for CH_4 is established by multiplying the maximum CH_4 generation potential (B_0) by a CH_4 conversion factor (MCF). The maximum CH_4 generation potential is set to 0.6 kg-CH_4/kg-BOD, given in the *2006 IPCC Guidelines*, and the MCF is set to 0.1, a default value for "Sea, river and lake discharge" of "Untreated systems".

$$EF_{CH4} = B_0 \times MCF$$

$$= 0.6 \text{ [kg-}CH_4\text{/kg-BOD]} \times 0.1$$
$$= 0.06 \text{ [kg-}CH_4\text{/kg-BOD]}$$

The emission factor for N_2O is calculated from the value of 0.005 kg N_2O-N/kg N after conversion of the units.

$$EF_{N2O} = 0.005 \text{ [kg-}N_2O\text{-N/kg-N]} \times 44/28$$
$$= 0.0079 \text{ [kg-}N_2O\text{/kg-N]}$$

- ***Activity Data***

Activity data to be calculated are the following sources:

- Domestic wastewater from households using *tandoku-shori johkasou*
- Domestic wastewater from households using vault toilets
- Domestic wastewater from households using on-site disposal systems

- Human waste and septic tank sludge dumped into the ocean
- Sewage sludge dumped into the ocean

Definition for each activity data is provided as in Table 7-89. Estimated activity data are shown in Table 7-90.

Table 7-89 Calculation method for activity data used for the calculation of GHG emissions from the natural decomposition of domestic wastewater

Item	Methane emission activity data	Nitrous oxide emission activity data
Tandoku-shori johkasou Vault toilet	User population [persons] × Unit BOD from domestic wastewater [g-BOD/person·day]	User population [persons] × Unit nitrogen from domestic wastewater [g-N/person·day]
On-site disposal *	Population using on-site disposal system [person] × Unit BOD from domestic wastewater [g-BOD/person·day]	Population using on-site disposal system [person] × Unit nitrogen from domestic wastewater [g-N/person·day]
Ocean dumping (Human waste, septic tank sludge)	Human waste dumped in ocean [kl] × BOD concentration in human waste [mg-BOD/l] + septic tank sludge dumped in ocean [kl] × BOD concentration in septic tank sludge [mg-BOD/l]	Human waste dumped in ocean [kl] × nitrogen concentration in septic tank sludge [mg-N/l] + septic tank sludge dumped in ocean [kl] × nitrogen concentration in septic tank sludge [mg-N/l]
Ocean dumping (Sewage sludge)	Sewage sludge dumped in ocean [kl] × BOD concentration in sewage sludge [mg-BOD/l]	Sewage sludge dumped in ocean [kl] × nitrogen concentration in sewage sludge [mg-N/l]

Source:
Volumes for *tandoku-shori johkasou*, vault toilets, on-site disposal systems and ocean dumping: Reference #8
Unit BOD and unit nitrogen from domestic wastewater: Reference #51
BOD concentration and nitrogen concentration in human waste and septic tank sludge: Reference #67
Note:
* A portion of the human waste in on-site disposal systems is utilized as fertilizer on farmlands in Japan. The nitrous oxide emission from this portion of human waste is already included in the "Direct soil emission (3.D.1.)" category in the Agriculture section, and therefore, not included in the calculation for this source.

Table 7-90 Activity data: Amount of organic material and nitrogen in untreated domestic wastewater and discharged into public water zone

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tandoku-shori johkasou	kt-BOD	367	381	341	267	251	232	226	215	204	194	191	181	173
Vault toilet	kt-BOD	568	429	298	203	190	177	165	156	146	136	130	120	113
On-site disposal	kt-BOD	46	21	9	4	3	3	8	2	2	2	2	1	1
Ocean dumping (Human waste)	kt-BOD	22	14	9	4	2	NO	NO	NO	NO	NO	NO	NO	NO
Ocean dumping (Sewege sludge)	kt-BOD	1	1	0.05	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	kt-BOD	1,003	845	658	478	446	412	399	373	351	333	322	302	287

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tandoku-shori johkasou	kt-N	18.3	19.1	17.0	13.4	12.5	11.6	11.3	10.7	10.2	9.7	9.6	9.0	8.6
Vault toilet	kt-N	28.4	21.5	14.9	10.2	9.5	8.8	8.3	7.8	7.3	6.8	6.5	6.0	5.6
On-site disposal	kt-N	2.3	1.1	0.5	0.2	0.2	0.1	0.4	0.1	0.1	0.1	0.1	0.1	0.1
Ocean dumping (Human waste)	kt-N	7.2	3.2	2.2	0.8	0.5	NO	NO	NO	NO	NO	NO	NO	NO
Ocean dumping (Sewege sludge)	kt-N	0.1	0.1	0.01	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	kt-N	56	45	35	24	23	21	20	19	18	17	16	15	14

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for the uncertainties in emission factors for CH_4 and N_2O in this category, the uncertainties in similar emission sources are substituted. As for the uncertainties in activity data, the uncertainties in domestic wastewater data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-91.

Table 7-91 Uncertainty assessment for natural decomposition of domestic wastewater on the category "Domestic wastewater (5.D.1.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Natural decomposition	CH_4	-58%	+58%	-10%	+10%	-59%	+59%	Since 2006 Guidelines provide the emission factors as default value for this category, the uncertainty is assessed in accordance with the default method in the guidelines.	The uncertainty in municipal waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	N_2O	-58%	+58%	-10%	+10%	-59%	+59%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in CH_4 is substituted based on expert judgment.		

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

No recalculations are conducted.

f) Category-specific Planned Improvements

No improvements are planned.

7.5.2. Industrial Wastewater (5.D.2.)

CH_4 and N_2O emissions from industrial effluent, which is treated by factories and other facilities in accordance with the regulations based on the Water Pollution Prevention Law and the Sewerage Law, are allocated to "Industrial wastewater treatment (5.D.2.-)" and CH_4 and N_2O emissions from landfill leachate treatment are allocated to "Landfill leachate treatment (5.D.2.-)" under the sub-category of "Industrial Wastewater (5.D.2.)".

7.5.2.1. Industrial Wastewater Treatment (5.D.2.-)

a) Category Description

CH_4 and N_2O emissions from industrial effluent, which is treated by factories and other facilities in accordance with the regulations based on the Water Pollution Prevention Law and the Sewerage Law, are allocated to "Industrial wastewater treatment (5.D.2.-)."

b) Methodological Issues

- ***Estimation Method***

In accordance with the decision tree of the *2006 IPCC Guidelines* (Page 6.19, Fig. 6.3), CH_4 and N_2O emissions are estimated for the industries that release organic-rich wastewater. Since default values given in the 2006 IPCC Guidelines are considered to be unsuited to Japan's circumstances, CH_4

emissions are estimated based on Japan's country-specific methodology, namely, by multiplying the annual amount of organic matter in industrial wastewater subject to report (BOD basis) by the CH4 emission factor per unit BOD that is based on Japan's country-specific wastewater handling. Because CH_4 is emitted in wastewater biological treatment processes, BOD-based activity data (amount of organic matter in wastewater degraded through biological treatment) is thought to be preferable to COD-based data. For this reason, CH_4 emissions are calculated using BOD in Japan. With regard to N_2O emissions, no estimation methodologies are given in the IPCC guidelines. Therefore, in the same manner for estimating CH_4 emissions, N_2O emissions are estimated by multiplying the amount of nitrogen in industrial wastewater by Japan's country-specific N_2O emission factor.

$$E = EF \times A$$

Where:

E	: Amount of CH_4 or N_2O emissions generated when treating industrial wastewater [kg-CH_4], [kg-N_2O]
EF	: Emission factor [kg-CH_4/kg-BOD], [kg-N_2O/kg-N]
A	: Annual amount of industrial wastewater treated at wastewater treatment facilities [m^3]

- ***Emission Factor***

No research applicable to the circumstances in Japan has been found for the amounts of CH_4 and N_2O generated from the industrial wastewater treatments. Therefore, emission factors are established by using with the ones used for the domestic wastewater treatment at sewage treatment plants (See "7.5.1.1. Sewage Treatment Plant (5.D.1.-)") because CH_4 and N_2O generation processes from both sources are considered to be closely resemble[3].

Since the ones used in "7.5.1.1. Sewage Treatment Plant (5.D.1.-)" are expressed in units of volume of wastewater treated [m^3], these emission factors are converted to units per amount of organic matter (BOD basis) and nitrogen by dividing the emission factor by the following concentrations of organic matter (BOD basis) and nitrogen in the wastewater intake at sewage treatment plants.

For the BOD concentration of runoff water, the "Planned Runoff Water Quality of Municipal Solid Domestic Wastewater" (180 mg-BOD/l) given in Guidelines and Explanation of Sewerage Facility Design (Japan Sewage Works Association, 2001) is used.

For the nitrogen concentration of runoff water, 37.2 mg-N/L is used, which is the simple average of total nitrogen concentrations of runoff water of sewage treatment plants obtained from the Sewage Statistics 2003 (Admin. Ed.).

CH_4 Emission factor

＝(CH_4 emission factor for emissions from domestic and commercial wastewater treatment & Sewage treatment plant)) / (BOD concentration in influent water)

＝8.8×10^{-4} [kg-CH_4/m^3] / 180 [mg-BOD/L]×1000

＝0.0049 [kg-CH_4/kg-BOD]

[3] Instead of the N_2O emission factors for the detail-classified treatments of domestic and commercial wastewater at sewage treatment plants in the above section, another country specific N_2O emission factor in the Reference #7 are applied for industrial wastewater treatment.

N_2O Emission factor

＝(Average of emission factor for water treatment processes
+ Average of emission factor for sludge treatment processes) / (N concentration in influent water)
＝(160.3 [mg-N_2O/m^3]＋0.6 [mg-N_2O/m^3]) / 37.2 [mg-N/L] × 1000
＝0.0043 [kg-N_2O/kg-N]

In Japan, CH_4 emissions generated by anaerobic wastewater treatment are entirely recovered. For a small amount of CH_4 emissions generated under partially anaerobic conditions created during aerobic treatment, a country-specific emission factor is applied for emission estimates because the condition for this particular CH_4 emission differs from that for the use of default value for the CH_4 emissions generated from anaerobic treatment defined in *the 2006 IPCC Guidelines*.

- ***Activity Data***

The activity data for CH_4 emission are estimated based on the amount of organic matter contained in wastewater using BOD concentrations. The emission estimates are conducted for the industries which generate large amount of CH4 emissions with high BOD concentrations from the treatment of wastewater referring to the industry types provided in the *Revised 1996 IPCC Guidelines* (Table 7-92). The amount of organic matter is obtained by sorting and aggregating by industry type according to the middle industrial classification provided by the Guidelines and Explanation of Sewage Facility Design (Japan Sewage Works Assosiation,2001).

The use of COD concentrations is required to report activity data on CRF; however, activity data are reported as “NE” because country-specific methodology is used for this source.

CH_4 Activity data

= Σ[(Amount of industrial wastewater flowing into wastewater treatment facilities)
× (Percentage of industrial wastewater treated at treatment facilities emitting CH_4)
× (Percentage of industrial wastewater treated on-site)
× (BOD concentration of runoff water)]

The activity data for N_2O emissions are obtained based on the amount of nitrogen contained in industrial wastewater and aggregated by the same industrial sub-category as that applied to the estimation of CH_4 emissions.

N_2O Activity data

= Σ[(Amount of industrial wastewater flowing into wastewater treatment facilities)
× (Percentage of industrial wastewater treated at treatment facilities emitting N_2O)
× (Percentage of industrial wastewater treated on-site)
× (Nitrogen concentration of runoff water)]

- ***Amount of Industrial Wastewater Inflowed into Wastewater Treatment Facilities***

The amount of water used for the treatment of products by industrial sub-category and the volume of water used for washing given in the *Table of Industrial Statistics - Land and Water* (Ministry of Economy, Trade and Industry) are used for the amount of industrial wastewater treated at wastewater treatment facilities.

➢ ***Percentage of Industrial Wastewater Treated at Facilities Generating CH_4***

Emissions of CH_4 from industrial wastewater treatment are believed to be generated from the treatment of wastewater with the activated sludge method and from the anaerobic treatment. Industrial wastewater treatment percentages for each industry code are set from the percentages of reported wastewater amounts in total wastewater, as given under "active sludge", "other biological treatment", "membrane treatment", "nitrification and denitrification" and "other advanced treatment" in the *Study on the Control of Wastewater loading* (Water and Air Environment Bureau, Ministry of the Environment).

➢ ***Percentage of Industrial Wastewater Treated at Facilities Generating N_2O***

Emissions of N_2O from industrial wastewater treatment are believed to be generated mainly from biological treatment processes such as denitrification. Data on the fraction of industrial wastewater treated at facilities generating CH_4 is also used for N_2O emission estimates.

➢ ***Percentage of Industrial Wastewater Treated On-site***

Percentage of industrial wastewater treated on-site is set at 1.0 in all industrial sub-categories because there is no statistical information available making it possible to ascertain this percentage.

➢ ***BOD and Nitrogen Concentrations in Runoff Wastewater***

For the BOD concentrations for industrial sub-categories, the BOD raw water quality for industrial sub-categories given in the *Guidelines and Analysis of Comprehensive Planning Surveys for the Provision of Water Mains, by Catchment Area 1999 Edition* (Japan Sewage Works Association) is used. For the nitrogen concentrations for industrial sub-categories, emission intensities (TN: Total Nitrogen) provided by the same survey for industrial sub-categories are used.

Table 7-92 BOD and nitrogen concentrations by industry type used for emission estimates

Industry code	Category of Manufacturing	mg-BOD/l	mg-N/l
9	Food manufacturing	1,467	62
10	Beverage, tobacco and feeding stuff manufacturing	1,138	77
11	Textile manufacturing	386	36
14	Pulp, paper and other paper manufacturing	556	37
16	Chemical industries	1,093	191
17	Petroleum products and coal product manufacturing	975	289
18	Plastic products manufacturing	268	11
19	Rubber products manufacturing	112	32
20	Chamois, chamois products and fur skin manufacturing	1,810	60

Table 7-93 BOD load [kt-BOD] and TN load [kt-N] of industrial wastewater

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
BOD load	kt-BOD	1,075	1,046	1,032	1,000	998	1,004	1,004	970	946	917	889	881	881
TN load	kt-N	89	87	76	89	88	89	94	90	89	88	87	86	86

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As for the uncertainties in emission factors for CH_4 and N_2O in this category, the uncertainties in similar emission sources are substituted. As for the uncertainties in activity data, the uncertainties in industrial wastewater data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-94.

Table 7-94 Uncertainty assessment for industrial wastewater treatment on the category "Industrial wastewater (5.D.2.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission/removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Industrial wastewater treatment	CH_4	-60%	+60%	-30%	+30%	-67%	+67%	The uncertainty is assessed based on expert judgment. (About two times larger than the uncertainty in the category of Sewage treatment plant)	The uncertainty in industrial waste statistics based on expert judgment is used.	Combined by using the formula for propagation of errors
	N_2O	-100%	+300%	-30%	+30%	-104%	+301%			

- ***Time-series Consistency***

Data on the percentage of industrial wastewater treated at CH_4- and N_2O-generating facilities since FY2001 are available only for FY2004. Therefore, data are interpolated and extrapolated for the remaining years. The emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Updating the data on the amount of industrial wastewater treated, emissions are recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

For future inventories, long-term efforts on further scientific investigations will be made to the following items:

- Improving the emission factors for emissions from industrial wastewater treatment for which currently the emission factors used for sewage treatment plants are substituted.
- Determining the amount of CH_4 recovery from industrial wastewater treatment

7.5.2.2. Landfill Leachate Treatment (5.D.2.-)

a) Category Description

CH_4 and N_2O emissions from landfill leachate treatment in MSW and IW landfill sites are estimated and allocated to "Landfill leachate treatment (5.D.2.-)."

b) Methodological Issues

- ***Estimation Method***

Potential BOD load [kg-BOD/year] and TN load [kg-N/year] to be remained in leachate percolated thorough organic waste disposed of in MSW and IW landfill sites are applied for its activity data, and the methodology for the natural decomposition of domestic wastewater given in *the 2006 IPCC Guidelines* is applied to estimate CH_4 and N_2O emissions from this source as described below:

$$E = EF \times L_i$$

E : CH_4 and N_2O emissions

EF : CH_4 and N_2O emission factor

L_i : Potential BOD load [kg-BOD/year] and TN load [kg-N/year] to be remained in leachate percolated thorough organic waste disposed of in MSW and IW landfill sites

- ***Emission Factors***

Emission factors for CH_4 and N_2O are determined in accordance with the methodology for the natural decomposition of domestic wastewater given in the *2006 IPCC Guidelines* as described below.

CH_4 Emission factor

According to *the 2006 IPCC Guidelines*, the emission factor for CH_4 is established by multiplying the maximum CH_4 generation potential (B_0) by a CH_4 conversion factor (MCF). The maximum CH_4 generation potential (B_0) is determined to be 0.6 kg-CH_4/kg-BOD which is a default value for "Domestic waste water" given in the *2006 IPCC Guidelines*, and MCF is determined to be 0.8 which is also a default value for "Anaerobic reactor" of "Treated systems" given in the *2006 IPCC Guidelines*.

$$EF_{CH4} = B_0 \times MCF$$

$= 0.6$ [kg-CH_4/kg-BOD]$\times$ 0.8

$= 0.48$ [kg-CH_4/kg-BOD]

B_0 : Maximum CH_4 generation potential [kg-CH_4/kg-BOD], IPCC default value:0.6)

MCF : CH_4 conversion factor (IPCC default value: 0.8)

N_2O Emission Factor

The emission factor for N_2O is determined from a default value of 0.005 (kg N_2O-N/kg N) given in the *2006 IPCC Guidelines* after unit conversion.

EF_N $= 0.005$ [kg-N_2O-N/kg N] $\times$ 44/28

$= 0.0079$ [kg-N_2O/kg N]

- ***Activity Data***

Based on *the Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector,* 2010, the Ministry of the Environment (Reference #18), the activity data for CH_4 and N_2O emission estimates are determined by establishing the ratio of organic and nitrogen contents to be remained in leachate for the amount of organic waste disposed of in MSW and IW landfill sites to obtain potential BOD load [kg-BOD/year] and TN load [kg-N/year].

CH_4 activity data

$$L_{BODi} = F_{BOD} \times W \times T_i$$

L_{BODi} : Potential BOD load to be remained in leachate percolated thorough organic waste disposed of in MSW and IW landfill sites [kg-BOD/year]

F_{BOD} : Ratio of organic contents for the amount of organic waste landfilled [kg-BOD/t] determined to be 0.188 [kg-BOD/t] based on Reference #18

W : Amount of organic waste landfilled with or without intermediate treatments including incineration ash [t/year] obtained by the *Cyclical Use of Waste Report*

T_i : Ratio of leachate to be biologically treated in landfill site [%] determined to be 87.6% based on Reference #18

N_2O activity data

$$L_{Tni} = F_{TN} \times W \times T_i$$

L_{BODi} : Potential TN load to be remained in leachate percolated thorough organic waste disposed of in MSW and IW landfill sites [kg-N/year]

F_{TN} : Ratio of nitrogen contents for the amount of organic waste landfilled [kg-N/t] determined to be 0.254 [kg-N/t] based on Reference #18

W : Amount of organic waste landfilled with or without intermediate treatments including incineration ash [t/year] obtained by the *Cyclical Use of Waste Report*

T_i : Ratio of leachate to be biologically treated in landfill site [%] determined to be 87.6% based on Reference #18

Table 7-95 BOD load [kt-BOD] and TN load [kt-N] of landfill leachate

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
BOD load	kt-BOD	1,075	1,046	1,032	1,000	998	1,004	1,004	970	946	917	889	881	881
TN load	kt-N	89	87	76	89	88	89	94	90	89	88	87	86	86

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As for the uncertainties in emission factors for CH_4 and N_2O in landfill leachate treatment, the uncertainties in similar emission sources are substituted. As for the uncertainties in activity data, the uncertainties in industrial wastewater data indicated in Table 7-2 are applied. Details of the uncertainty assessment on this category are indicated in the Table 7-96.

Table 7-96Uncertainty assessment for landfill leachate treatment on the category "Industrial wastewater (5.D.2.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Landfill leachate treatment	CH_4	-39%	+39%	-100%	+100%	-107%	+107%	The uncertainty is quoted from "Report on Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, in FY2009", a source of emission factors.	Due to the lack of information for the uncertainty of the activity data, the uncertainty is assessed by expert judgment.	Combined by using the formula for propagation of errors
	N_2O	-39%	+39%	-100%	+100%	-107%	+107%	Due to the lack of information for the uncertainty of the emission factor, the uncertainty in the EF of CH4 in this category is substituted based on expert judgment.		

- ***Time-series Consistency***

As described in detail in the preceding sections, emissions are calculated in a consistent manner.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Updating the statistical data, emission estimates for FY2004 and after were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

7.6. Other (5.E.)

In this category, CO_2 emissions as a result of the decomposition of petroleum-derived surfactants are calculated. Estimated greenhouse gas emissions from category 'Other' are shown in Table 7-97.

Table 7-97 Categories whose emissions are estimated for Other (5.E.)

Category	Waste type	Treatment type	CO_2	CH_4	N_2O
5.E.1. (7.6.1)	Petroleum-Derived Surfactants	Decomposition at wastewater treatment facilities and/or the environment	○	NA	NA

In FY2014, emissions from this source category are 617 kt-CO_2 eq. and accounted for 0.05% of the national total emissions (excluding LULUCF). The emissions from this source category had decreased by 12.3% compared to those in FY1990. This emission decrease is primarily due to the decrease in CO_2 emissions from the use of alkylbenzenes by introduction of the Pollutant Release and Transfer Register (PRTR).

Table 7-98 GHG emissions from category 'Other' (5.E.)

Gas	Category	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO_2	5.E. Other (Decomposition of petroleum-derived surfactants)	kt-CO_2	703	668	656	507	522	561	530	514	527	524	528	605	617

7.6.1. Decomposition of Petroleum-Derived Surfactants (5.E.-)

a) Category Description

Surfactants are used for various cleaning activities at home and factories in Japan. Petroleum-derived surfactants discharged into wastewater treatment facilities and into the environment, and emit CO_2. As this emission source did not correspond to any of the existing waste categories (5.A. to 5.D.), it is included in the "Other (5.E.)" section. Because "CH_4 and N_2O emissions from wastewater treatment" and "CO_2 emissions from the decomposition of petroleum-derived surfactants" concern different types of gas, they are unrelated to each other and pose no duplicate inventory issues.

b) Methodological Issues

- ***Estimation Method***

As neither the *2006 IPCC Guidelines* specified a method for determining CO_2 emissions, a method specifically established in Japan is applied to the calculation. Because carbon contained in surfactants

that emitted into wastewater treatment facilities and into the environment is eventually oxidized to CO_2 and emitted into the atmosphere as a result of surfactants decomposition, CO_2 emissions are estimated based on the amount of carbon contained in surfactants that emitted into wastewater treatment facilities and into the environment.

Based on the facts stated above, the CO_2 emissions are calculated by multiplying the volume of the petroleum-derived surfactant for each type of raw material by the carbon content of each of the materials. The calculation covered synthetic alcohols, alkylbenzenes, alkylphenols, and ethylene oxide. Some of the carbon contained in surfactants discharged into wastewater treatment facilities are adsorbed and assimilated by sludge. However, this portion of carbon is not decomposed biologically. It is released into the atmosphere as CO_2 through incineration and landfilling of sludge. Therefore, the emission is included in CO_2 emission estimates.

- ***Emission Factor***

Emission factor is determined for each type of material by calculating the amount of CO_2, expressed in kg that is emitted from the decomposition of 1 t of a surfactant using the average carbon content in the molecules.

$$EF_i = C_i \times 1{,}000 \times 44/12$$

EF_i : Emission factor of petroleum-derived raw material *i* used in a surfactant
C_i : Average carbon content of petroleum-derived raw material *i* used in a surfactant

Table 7-99 Average carbon content of surfactants, by petroleum-derived raw material

Raw material	Carbon number	Molecular weight	Carbon content	Basis for determination
Synthetic alcohol	12	186	77.4%	C12-alcohol as the main constituent.
Alkylbenzene	18	250	86.4%	C12-alkylbenzene as the main constituent.
Alkylphenol	15	210	85.7%	C9-alkylphenol as the main constituent.
Ethylene oxide	2	44	54.5%	Based on ethylene oxide molecules (C_2H_4O)

- ***Activity Data***

Activity data is the amount of raw materials consumed for petroleum-derived surfactants. As some of the surfactants produced in Japan are exported, the activity data are determined by multiplying the volume of raw materials used in the surfactants obtained from the statistical data for surfactant use by an import/export adjustment factor.

➢ ***Volume of Surfactants Used***

The volumes of the use of surfactant by material are obtained from the consumption of raw materials for surfactants indicated in the *Chemical Industry Statistical Yearbook*. As there is no compilation of usage since FY2002, the volume of use is estimated using the simple averages (k value) of ratio of consumption and production in the period from FY1990 to FY2001.

➢ ***Export/import Correction Factor***

Correction factor is calculated from the export/import statistics in *International Trade Statistics* by the Customs Bureau of the Ministry of Finance for categories of anionic surfactants, cationic surfactants, non-ionic surfactants, and other organic surfactants and the volume of surfactants used. As some of the materials for surfactants are used in several types of surfactants, an average of the export/import

correction factor is weighted by surfactant production volume as necessary to calculate the correction factor for each classification of surfactant.

Export/Import correction factor
= (surfactant production + surfactants imported – surfactants exported) / surfactant production

Table 7-100 Activity data associated with decomposition of petroleum-based surfactants

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Synthetic alcohol	t	29,239	16,253	28,285	31,609	34,575	36,896	32,988	32,872	33,750	34,870	36,193	43,324	42,948
Alkyl benzene	t	105,432	102,794	80,832	47,349	46,281	51,251	55,442	50,206	50,519	46,369	44,502	44,980	47,385
Alkyl phenol	t	10,141	8,798	7,454	3,448	3,184	3,084	2,338	2,044	2,054	2,263	2,910	4,318	4,885
Ethylene oxide	t	124,984	132,175	146,509	127,150	132,828	141,104	125,628	126,301	131,148	134,532	136,679	161,969	163,781

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty in emission factor for CO_2 is evaluated by using molecular weight which is used for calculation of emission factors, based on expert judgment. As for activity data, the same assessment as municipal waste statistics is applied based on expert judgment since information on the uncertainty is not available.

Table 7-101 Uncertainty assessment for decomposition of petroleum-derived surfactants on the category "Other (5.E.-)"

Item	GHGs	Emission /removal factor uncertainty [%]		Activity data uncertainty [%]		Emission /removal uncertainty [%]		The method of evaluating uncertainty in emission factor	The method of evaluating uncertainty in activity data	The method of evaluating uncertainty in emissions/ removals
		(-)	(+)	(-)	(+)	(-)	(+)			
Decomposition of petroleum-derived surfactants	CO_2	-1%	+1%	-10%	+10%	-10%	+10%	The uncertainty is assessed by using molecular weight data based on expert judgment.	Due to the lack of information for the uncertainty of the activity data, the uncertainty in municipal waste statistics is substituted by expert judgment.	Combined by using the formula for propagation of errors

- ***Time-series Consistency***

Consistent methodology is used in the estimation. However, data on the amount of raw materials consumed for surfactants have become not available since FY2002 and activity data are estimated from the production amount of the surfactants.

d) Category-specific QA/QC and Verification

General inventory QC procedures are conducted in accordance with the *2006 IPCC Guidelines*. The focus of general inventory QC is on the checking of the parameters for activity data and emission factors and the archiving of reference materials. QA/QC activities are summarized in Chapter 1.

e) Category-specific Recalculations

Updating the statistical data, emission estimates for FY2012 and FY2013 were recalculated. See Chapter 10 for impact on trend.

f) Category-specific Planned Improvements

No improvements are planned.

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Chapter 8. Other

8.1. Overview of Sector

UNFCCC Reporting Guidelines (Decision 24/CP.19) paragraph 29 indicates that Annex I Parties should report and explicitly describe the details of emissions from each country-specific source of gases which are not part of the *IPCC Guidelines*. According to this requirement, emissions from the Other sector (CRF sector 6) are indicated below.

8.2. CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, and NF_3

Among CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3, no emissions and removals are reported in Other sector.

8.3. NOx, CO, NMVOC, and SO_x

Among precursors (NOx, CO, NMVOC) and SO_x, CO emissions from smoking are reported in Other sector (see Annex 3).

Chapter 9. Indirect CO_2 and Nitrous Oxide Emissions

9.1. Overview of Sector

Although Parties may now choose to report indirect CO_2, in accordance with paragraph 29 of the UNFCCC Inventory Reporting Guidelines, Japan has elected not to report indirect CO_2 emissions from the atmospheric oxidation of CH_4, CO and NMVOCs, or indirect N_2O emissions arising from sources other than those in the agriculture and LULUCF sectors.

Refer to Annex 3 for information on the following precursor gases: carbon monoxide (CO), nitrogen oxides (NO_X) and non-methane volatile organic compounds (NMVOCs), as well as sulfur oxides (SO_X).

Chapter 10. Recalculation and Improvements

10.1. Explanations and Justifications for Recalculations

This section explains improvements on estimation of emissions and removals in the inventory submitted in 2016.

In accordance with the UNFCCC Reporting Guidelines and the *2006 IPCC Guidelines*, Annex I Parties should recalculate their inventories for the base year and all subsequent years of the times series in the cases of 1) application of new estimation methods, 2) addition of new categories for emissions and removals, and 3) data refinement. Major changes from the previous inventory are indicated below.

10.1.1. General Issues

As Japan's own specific circumstance, it can generally be said that activity data for the latest year available at the time when the inventory is compiled are often revised in the year following the submission year because of such as the publication of data in the fiscal year basis. In the national inventory submitted this year, activity data in many sources for 2013 have been changed and as a result, the emissions from those sources for the inventory year have been recalculated.

10.1.2. Recalculations in Each Sector

The information of recalculation for sectors (energy; industrial processes and product use; agriculture; land use, land-use change and forestry; and waste), occurring due to Japan's own specific circumstance and needs, is described separately under sections named as "Category-specific Recalculations" in Chapters 3 to 7.

10.2. Implications for Emission Levels

The following shows the changes made to the overall emission estimates due to the recalculations indicated in "Section 10.1. Explanation and Justification for Recalculations".

10.2.1. GHG Inventory

Compared to the values reported in the previous year's inventory, total emissions excluding the LULUCF sector in the base year (1990) under the UNFCCC increased by 0.04%, and the total emissions in year 2013 increased by 0.01% (Table 10-1).

Comparisons with the previous year's inventory for each sector, by category and by gas are as shown in Table 10-2 to Table 10-6. See each category for details on the reasons of recalculations.

Table 10-1 Comparison of emissions and removals in the inventories submitted in 2015 and 2016

[Mt-CO_2 eq.]

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
CO_2	JNGI2015	1,095.5	1,096.0	1,103.2	1,092.8	1,154.3	1,166.3	1,174.7	1,168.9	1,133.1	1,167.6	1,185.8	1,168.9	1,204.2	1,199.9	1,201.4	1,214.4	1,197.7	1,235.7	1,162.3	1,094.3	1,141.9	1,191.3	1,222.5	1,245.8
with LULUCF	JNGI2016	1,096.4	1,096.7	1,104.2	1,093.5	1,155.5	1,167.5	1,175.7	1,170.2	1,134.3	1,168.6	1,187.2	1,170.2	1,205.6	1,201.3	1,202.8	1,215.7	1,200.5	1,237.1	1,163.7	1,095.7	1,143.6	1,192.3	1,223.4	1,246.2
	difference	*0.08%*	*0.06%*	*0.09%*	*0.06%*	*0.10%*	*0.10%*	*0.08%*	*0.11%*	*0.10%*	*0.09%*	*0.12%*	*0.11%*	*0.11%*	*0.12%*	*0.11%*	*0.11%*	*0.23%*	*0.12%*	*0.12%*	*0.13%*	*0.15%*	*0.09%*	*0.07%*	*0.04%*
CO_2	JNGI2015	1,154.4	1,163.0	1,172.8	1,166.4	1,227.2	1,240.8	1,253.8	1,251.3	1,216.7	1,251.7	1,272.5	1,255.8	1,292.8	1,297.9	1,296.8	1,304.4	1,282.2	1,318.2	1,234.0	1,161.1	1,211.5	1,260.8	1,295.5	1,310.7
without LULUCF	JNGI2016	1,156.0	1,164.5	1,174.6	1,167.7	1,228.9	1,242.5	1,255.3	1,253.1	1,218.3	1,253.1	1,274.3	1,257.4	1,294.4	1,299.5	1,298.4	1,305.9	1,285.2	1,319.8	1,235.5	1,162.6	1,213.0	1,261.9	1,296.2	1,311.5
	difference	*0.14%*	*0.12%*	*0.15%*	*0.11%*	*0.14%*	*0.14%*	*0.12%*	*0.14%*	*0.13%*	*0.11%*	*0.14%*	*0.13%*	*0.13%*	*0.13%*	*0.12%*	*0.12%*	*0.23%*	*0.12%*	*0.12%*	*0.13%*	*0.12%*	*0.09%*	*0.05%*	*0.06%*
CH_4	JNGI2015	48.7	46.9	48.2	42.9	48.0	45.9	44.6	43.8	41.5	41.5	41.6	40.3	39.6	37.7	39.1	39.0	38.3	38.5	38.3	37.3	38.3	37.3	36.5	36.1
with LULUCF	JNGI2016	48.7	46.9	48.1	42.9	48.0	45.9	44.6	43.8	41.4	41.5	41.5	40.3	39.6	37.6	39.1	39.0	38.3	38.5	38.3	37.2	38.3	37.3	36.5	36.1
	difference	*-0.01%*	*-0.01%*	*-0.03%*	*-0.04%*	*-0.03%*	*-0.04%*	*-0.05%*	*-0.06%*	*-0.06%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.08%*	*-0.08%*	*-0.06%*	*-0.06%*	*-0.05%*	*-0.08%*	*-0.06%*	*0.02%*	*0.05%*	*0.09%*	*0.07%*
CH_4	JNGI2015	48.6	46.9	48.1	42.8	47.9	45.8	44.5	43.7	41.4	41.5	41.5	40.3	39.5	37.6	39.0	39.0	38.2	38.5	38.3	37.2	38.3	37.3	36.4	36.0
without LULUCF	JNGI2016	48.6	46.9	48.1	42.8	47.9	45.8	44.5	43.7	41.4	41.4	41.5	40.2	39.5	37.6	39.0	38.9	38.2	38.5	38.2	37.2	38.3	37.3	36.5	36.1
	difference	*-0.01%*	*-0.01%*	*-0.03%*	*-0.04%*	*-0.03%*	*-0.04%*	*-0.05%*	*-0.06%*	*-0.06%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.08%*	*-0.08%*	*-0.06%*	*-0.06%*	*-0.05%*	*-0.08%*	*-0.06%*	*0.02%*	*0.05%*	*0.09%*	*0.07%*
N_2O	JNGI2015	32.2	31.9	32.0	31.9	33.2	33.5	34.7	35.4	33.9	27.8	30.3	26.8	26.3	26.1	26.2	25.8	25.8	25.2	24.3	23.9	23.5	23.0	22.7	22.7
with LULUCF	JNGI2016	31.1	30.7	30.9	30.8	32.1	32.4	33.5	34.3	32.7	26.6	29.2	25.7	25.2	25.1	25.1	24.7	24.7	24.2	23.3	22.8	22.5	22.0	21.6	21.7
	difference	*-3.69%*	*-3.67%*	*-3.63%*	*-3.62%*	*-3.48%*	*-3.46%*	*-3.36%*	*-3.26%*	*-3.38%*	*-4.10%*	*-3.72%*	*-4.16%*	*-4.16%*	*-4.12%*	*-4.04%*	*-4.05%*	*-4.03%*	*-4.11%*	*-4.25%*	*-4.34%*	*-4.34%*	*-4.44%*	*-4.80%*	*-4.45%*
N_2O	JNGI2015	31.9	31.6	31.7	31.6	32.9	33.2	34.4	35.1	33.6	27.5	30.1	26.5	26.0	25.9	25.9	25.5	25.5	25.0	24.1	23.6	23.3	22.8	22.5	22.5
without LULUCF	JNGI2016	30.8	30.5	30.6	30.5	31.8	32.2	33.3	34.1	32.5	26.4	29.0	25.5	25.0	24.9	24.9	24.5	24.5	24.0	23.1	22.6	22.3	21.8	21.4	21.5
	difference	*-3.42%*	*-3.40%*	*-3.38%*	*-3.37%*	*-3.24%*	*-3.24%*	*-3.16%*	*-3.08%*	*-3.19%*	*-3.89%*	*-3.54%*	*-3.96%*	*-3.96%*	*-3.94%*	*-3.88%*	*-3.90%*	*-3.89%*	*-3.98%*	*-4.14%*	*-4.23%*	*-4.24%*	*-4.34%*	*-4.71%*	*-4.36%*
HFCs	JNGI2015	15.9	17.3	17.8	18.1	21.1	25.2	24.6	24.4	23.7	24.4	22.8	19.5	16.2	16.2	12.4	12.7	14.5	16.6	19.2	20.8	23.1	25.8	29.1	31.8
	JNGI2016	15.9	17.3	17.8	18.1	21.1	25.2	24.6	24.4	23.7	24.4	22.9	19.5	16.2	16.2	12.4	12.8	14.6	16.7	19.3	20.9	23.3	26.1	29.3	32.1
	difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.01%*	*0.02%*	*0.05%*	*0.11%*	*0.17%*	*0.34%*	*0.45%*	*0.54%*	*0.63%*	*0.69%*	*0.76%*	*0.83%*	*0.87%*	*0.90%*	*0.98%*
PFCs	JNGI2015	6.5	7.5	7.6	10.9	13.4	17.6	18.3	20.0	16.6	13.1	11.9	9.9	9.2	8.9	9.2	8.6	9.0	7.9	5.7	4.0	4.2	3.8	3.4	3.3
	JNGI2016	6.5	7.5	7.6	10.9	13.4	17.6	18.3	20.0	16.6	13.1	11.9	9.9	9.2	8.9	9.2	8.6	9.0	7.9	5.7	4.0	4.2	3.8	3.4	3.3
	difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
SF_6	JNGI2015	12.9	14.2	15.6	15.7	15.0	16.4	17.0	14.5	13.2	9.2	7.0	6.1	5.7	5.4	5.3	5.1	5.2	4.8	4.2	2.5	2.5	2.3	2.3	2.2
	JNGI2016	12.9	14.2	15.6	15.7	15.0	16.4	17.0	14.5	13.2	9.2	7.0	6.1	5.7	5.4	5.3	5.1	5.2	4.7	4.2	2.4	2.4	2.2	2.2	2.1
	difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.21%*	*-0.29%*	*-0.44%*	*-0.69%*	*-1.13%*	*-1.81%*	*-2.26%*	*-2.82%*	*-2.95%*
NF_3	JNGI2015	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.4	1.2	1.1	1.2	1.2	1.2	1.4	1.6	1.3	1.4
	JNGI2016	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.3	0.3	0.4	1.2	1.1	1.2	1.2	1.2	1.4	1.6	1.3	1.4
	difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
Total	JNGI2015	1,211.8	1,213.9	1,224.5	1,212.5	1,285.1	1,305.2	1,314.1	1,307.3	1,262.2	1,283.8	1,299.6	1,271.6	1,301.6	1,294.4	1,293.9	1,306.9	1,291.7	1,329.9	1,255.2	1,183.9	1,234.9	1,285.1	1,317.7	1,343.1
with LULUCF	JNGI2016	1,211.4	1,213.5	1,224.3	1,212.0	1,285.2	1,305.2	1,313.8	1,307.3	1,262.2	1,283.7	1,299.9	1,271.8	1,301.8	1,294.7	1,294.2	1,307.2	1,293.4	1,330.3	1,255.7	1,184.4	1,235.8	1,285.3	1,317.7	1,342.8
	difference	*-0.03%*	*-0.04%*	*-0.01%*	*-0.04%*	*0.00%*	*0.00%*	*-0.02%*	*0.01%*	*0.00%*	*-0.01%*	*0.02%*	*0.01%*	*0.02%*	*0.02%*	*0.03%*	*0.02%*	*0.14%*	*0.03%*	*0.04%*	*0.04%*	*0.07%*	*0.01%*	*0.00%*	*-0.02%*
Total	JNGI2015	1,270.2	1,280.6	1,293.7	1,285.6	1,357.6	1,379.3	1,392.7	1,389.3	1,345.4	1,367.6	1,386.0	1,358.2	1,389.8	1,392.1	1,389.0	1,396.5	1,375.8	1,412.2	1,326.6	1,250.4	1,304.3	1,354.3	1,390.5	1,407.8
without LULUCF	JNGI2016	1,270.7	1,280.9	1,294.4	1,285.9	1,358.3	1,379.9	1,393.1	1,389.9	1,345.8	1,367.9	1,386.7	1,358.7	1,390.3	1,392.7	1,389.6	1,397.1	1,377.9	1,412.8	1,327.2	1,251.0	1,304.9	1,354.6	1,390.3	1,407.9
	difference	*0.04%*	*0.03%*	*0.06%*	*0.02%*	*0.05%*	*0.05%*	*0.03%*	*0.04%*	*0.03%*	*0.02%*	*0.05%*	*0.04%*	*0.04%*	*0.04%*	*0.04%*	*0.04%*	*0.15%*	*0.05%*	*0.04%*	*0.05%*	*0.05%*	*0.02%*	*-0.01%*	*0.01%*

Table 10-2 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Energy sector)

1. Energy		[Mt-CO_2 eq.]																								
Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A. Fuel Combustion	CO_2	JNGI2015	352.8	355.9	362.7	346.4	387.4	377.0	379.2	377.0	365.0	384.0	393.1	383.0	414.2	430.9	427.9	448.0	436.5	498.7	473.8	436.8	461.2	518.8	561.6	566.6
1. Energy Industries		JNGI2016	352.8	355.9	362.7	346.4	387.4	377.0	379.2	377.0	365.0	384.0	393.1	383.0	414.2	430.9	427.9	447.9	436.5	498.8	473.8	436.8	461.2	518.6	561.9	564.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.04%*	*0.04%*	*-0.43%*
	CH_4	JNGI2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3
		JNGI2016	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3
		difference	*-0.68%*	*-0.71%*	*-0.76%*	*-0.85%*	*-0.95%*	*-1.01%*	*-0.98%*	*-1.11%*	*-1.10%*	*-1.24%*	*-1.86%*	*-2.58%*	*-2.78%*	*-3.35%*	*-3.06%*	*-1.97%*	*-1.73%*	*-1.16%*	*-0.73%*	*-0.19%*	*9.31%*	*12.12%*	*14.19%*	*10.65%*
	N_2O	JNGI2015	1.2	1.2	1.2	1.3	1.4	1.7	1.8	1.9	1.9	2.0	2.1	2.2	2.2	2.2	2.2	2.4	2.4	2.5	2.4	2.4	2.4	2.6	2.6	2.6
		JNGI2016	1.2	1.2	1.2	1.3	1.4	1.7	1.8	1.9	1.9	2.0	2.1	2.2	2.2	2.2	2.2	2.4	2.4	2.5	2.4	2.4	2.4	2.6	2.6	2.6
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.02%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.02%*	*-0.42%*
A. Fuel Combustion	CO_2	JNGI2015	378.6	373.7	366.7	365.7	375.2	381.2	385.5	385.5	362.3	369.1	377.9	372.4	383.5	382.6	384.7	373.0	377.2	363.3	330.2	301.5	337.0	333.4	332.7	338.1
2. Manufacturing Industries		JNGI2016	380.1	375.1	368.5	367.0	376.9	382.9	386.9	387.2	363.9	370.5	379.7	374.0	385.1	384.3	386.2	374.6	378.7	364.8	331.6	302.9	338.4	334.8	333.7	341.8
and Construction		*difference*	*0.41%*	*0.37%*	*0.49%*	*0.35%*	*0.45%*	*0.44%*	*0.38%*	*0.44%*	*0.42%*	*0.38%*	*0.46%*	*0.42%*	*0.42%*	*0.44%*	*0.41%*	*0.42%*	*0.41%*	*0.42%*	*0.45%*	*0.48%*	*0.42%*	*0.43%*	*0.32%*	*1.07%*
	CH_4	JNGI2015	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.5	0.5
		JNGI2016	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.5	0.5
		difference	*0.12%*	*0.09%*	*0.09%*	*0.08%*	*0.09%*	*0.11%*	*0.07%*	*0.09%*	*0.09%*	*0.10%*	*0.08%*	*0.06%*	*0.05%*	*0.03%*	*0.01%*	*0.00%*	*-0.02%*	*-0.03%*	*-0.03%*	*-0.01%*	*0.00%*	*0.01%*	*0.01%*	*3.45%*
	N_2O	JNGI2015	1.4	1.4	1.5	1.6	1.7	1.8	1.9	2.0	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.9	1.8	1.8	1.9
		JNGI2016	1.4	1.5	1.5	1.6	1.7	1.8	1.9	2.0	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.9	1.8	1.8	1.9
		difference	*0.90%*	*0.83%*	*0.85%*	*0.66%*	*0.44%*	*0.18%*	*0.12%*	*0.09%*	*0.02%*	*-0.02%*	*-0.03%*	*-0.04%*	*-0.04%*	*0.29%*	*0.21%*	*0.21%*	*0.20%*	*0.20%*	*0.31%*	*0.14%*	*-0.27%*	*-0.24%*	*-0.30%*	*0.44%*
A. Fuel Combustion	CO_2	JNGI2015	200.2	212.7	218.9	222.6	231.6	240.5	246.9	248.3	246.4	250.3	249.0	253.0	248.7	244.4	238.6	232.7	228.3	226.7	218.2	214.8	215.5	212.7	217.6	215.8
3. Transport		JNGI2016	200.2	212.7	218.9	222.6	231.6	240.5	246.9	248.3	246.4	250.3	249.0	253.0	248.7	244.4	238.6	232.7	229.7	226.7	218.2	214.8	215.5	212.7	217.4	215.8
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.61%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.08%*	*0.00%*
	CH_4	JNGI2015	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		JNGI2016	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		difference	*-5.16%*	*-5.12%*	*-5.10%*	*-5.13%*	*-5.11%*	*-5.18%*	*-5.17%*	*-5.10%*	*-5.17%*	*-5.14%*	*-5.29%*	*-5.29%*	*-5.24%*	*-5.43%*	*-5.42%*	*-5.45%*	*-5.40%*	*-5.47%*	*-5.56%*	*-5.81%*	*-5.21%*	*-5.53%*	*-7.05%*	*-7.54%*
	N_2O	JNGI2015	4.0	4.1	4.2	4.1	4.2	4.3	4.4	4.4	4.3	4.3	4.2	4.0	3.8	3.5	3.2	3.0	2.8	2.7	2.5	2.4	2.2	2.1	2.0	2.0
		JNGI2016	3.7	3.9	4.0	3.9	4.0	4.1	4.2	4.2	4.1	4.1	4.0	3.8	3.6	3.3	3.0	2.8	2.6	2.5	2.4	2.2	2.1	1.9	1.8	1.7
		difference	*-5.35%*	*-5.33%*	*-5.24%*	*-5.19%*	*-5.16%*	*-5.17%*	*-5.17%*	*-5.14%*	*-5.17%*	*-5.19%*	*-5.25%*	*-5.29%*	*-5.30%*	*-5.56%*	*-5.62%*	*-5.80%*	*-6.17%*	*-6.62%*	*-7.07%*	*-7.69%*	*-7.43%*	*-8.15%*	*-10.26%*	*-11.50%*
A. Fuel Combustion	CO_2	JNGI2015	145.0	141.8	144.6	153.3	150.9	159.1	158.3	158.7	167.1	172.5	176.0	173.6	175.9	170.3	176.8	181.2	171.5	161.5	146.3	151.2	139.3	137.8	124.6	129.2
4. Other Sectors		JNGI2016	145.0	141.8	144.6	153.3	150.9	159.1	158.3	158.7	167.1	172.5	176.0	173.6	175.9	170.2	176.8	181.2	171.5	161.5	146.3	151.2	139.3	137.8	124.3	129.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.22%*	*0.14%*
	CH_4	JNGI2015	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.4	0.9	0.7	0.7	0.7
		JNGI2016	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.4	0.9	0.7	0.7	0.7
		difference	*4.87%*	*4.57%*	*3.76%*	*3.10%*	*2.92%*	*2.47%*	*2.50%*	*2.24%*	*2.04%*	*1.71%*	*1.54%*	*1.51%*	*1.48%*	*1.22%*	*1.14%*	*0.92%*	*0.85%*	*0.95%*	*0.66%*	*0.93%*	*0.41%*	*0.60%*	*0.66%*	*0.69%*
	N_2O	JNGI2015	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.2	0.3
		JNGI2016	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3
		difference	*17.46%*	*16.73%*	*14.01%*	*11.11%*	*9.57%*	*7.95%*	*7.47%*	*6.82%*	*6.36%*	*5.53%*	*5.09%*	*5.17%*	*5.09%*	*4.89%*	*4.73%*	*4.28%*	*4.34%*	*4.72%*	*3.53%*	*4.27%*	*3.69%*	*5.44%*	*5.95%*	*5.56%*
B. Fugitive Emissions	CO_2	JNGI2015	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1. Solid Fuels		JNGI2016	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	CH_4	JNGI2015	4.8	4.2	3.8	3.1	2.7	2.4	2.1	1.9	1.7	1.7	1.6	1.3	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
		JNGI2016	4.8	4.2	3.8	3.1	2.7	2.4	2.1	1.9	1.7	1.7	1.6	1.3	0.8	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
B. Fugitive Emissions	CO_2	JNGI2015	0.2	0.2	0.2	0.2	0.2	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5
2. Oil and Natural Gas		JNGI2016	0.2	0.2	0.2	0.2	0.2	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.03%*	*-0.01%*	*0.00%*	*0.00%*	*0.00%*	*-8.65%*
	CH_4	JNGI2015	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3
		JNGI2016	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	0.3
		difference	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.23%
	N_2O	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
1. Total	GHG	JNGI2015	1,090	1,097	1,106	1,100	1,157	1,171	1,183	1,182	1,153	1,188	1,208	1,194	1,234	1,239	1,239	1,246	1,224	1,261	1,179	1,114	1,163	1,213	1,246	1,259
		JNGI2016	1,091	1,098	1,107	1,101	1,159	1,172	1,184	1,184	1,154	1,189	1,210	1,195	1,235	1,241	1,240	1,247	1,227	1,262	1,180	1,115	1,164	1,214	1,247	1,261
		difference	*0.13%*	*0.11%*	*0.14%*	*0.10%*	*0.13%*	*0.12%*	*0.11%*	*0.12%*	*0.11%*	*0.10%*	*0.13%*	*0.11%*	*0.11%*	*0.11%*	*0.11%*	*0.11%*	*0.23%*	*0.11%*	*0.11%*	*0.11%*	*0.11%*	*0.09%*	*0.06%*	*0.09%*

Table 10-3 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Industrial processes and product use sector) (1/2)

2. Industrial Processes and Product Use
(1/2) [Mt-CO_2 eq.]

Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A. Mineral Products	CO_2	JNGI2015	49.2	50.5	51.0	50.2	51.3	51.1	51.5	48.8	43.8	43.6	43.9	43.0	40.5	40.1	39.8	41.2	41.2	40.2	37.4	32.8	32.8	33.1	33.7	35.1
		JNGI2016	49.2	50.5	51.0	50.2	51.3	51.1	51.5	48.8	43.8	43.6	43.9	43.0	40.5	40.1	39.8	41.2	41.2	40.2	37.4	32.8	32.7	33.1	33.7	35.1
		difference	*0.00%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.00%*	*0.01%*	*0.01%*	*0.01%*	*0.03%*	*0.04%*	*0.05%*	*0.02%*	*-0.02%*	*-0.04%*	*-0.11%*	*-0.17%*
B. Chemical Industry	CO_2	JNGI2015	7.0	6.9	6.8	6.3	6.8	6.9	7.0	7.0	6.4	6.9	6.8	6.3	6.2	6.0	6.1	5.8	5.8	5.9	5.1	4.8	5.4	5.1	4.6	4.8
		JNGI2016	7.0	7.0	6.8	6.4	6.8	7.0	7.1	7.1	6.4	6.9	6.8	6.3	6.2	6.0	6.1	5.8	5.9	6.0	5.1	4.9	5.4	5.1	4.6	4.8
		difference	*0.85%*	*0.79%*	*0.30%*	*0.59%*	*0.54%*	*0.99%*	*0.28%*	*0.40%*	*0.32%*	*0.41%*	*0.53%*	*0.51%*	*0.43%*	*0.50%*	*0.50%*	*0.53%*	*0.50%*	*0.47%*	*0.53%*	*0.59%*	*0.57%*	*0.59%*	*0.60%*	*0.51%*
	CH_4	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*1.71%*	*1.61%*	*0.51%*	*1.07%*	*0.88%*	*1.55%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.27%*
	N_2O	JNGI2015	9.6	9.1	9.0	8.7	9.8	9.7	10.7	11.3	10.0	3.8	6.3	3.0	2.8	2.9	3.2	2.7	2.9	2.2	2.4	2.5	2.0	1.7	1.4	1.4
		JNGI2016	9.6	9.1	9.0	8.7	9.8	9.7	10.7	11.3	10.0	3.8	6.3	3.0	2.8	2.9	3.2	2.7	2.9	2.2	2.4	2.5	2.0	1.7	1.4	1.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	HFCs	JNGI2015	15.9	17.3	17.6	17.1	18.9	22.0	20.3	19.0	17.7	18.0	16.0	12.2	8.1	6.9	1.9	1.0	1.2	0.6	0.9	0.3	0.2	0.2	0.1	0.1
		JNGI2016	15.9	17.3	17.6	17.1	18.9	22.0	20.3	19.0	17.7	18.0	16.0	12.2	8.1	6.9	1.9	1.0	1.2	0.6	0.9	0.3	0.2	0.2	0.1	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	PFCs	JNGI2015	0.3	0.4	0.4	0.6	0.7	0.9	1.2	1.7	1.6	1.6	1.7	1.3	1.3	1.2	1.1	1.0	1.1	1.0	0.6	0.5	0.2	0.2	0.1	0.1
		JNGI2016	0.3	0.4	0.4	0.6	0.7	0.9	1.2	1.7	1.6	1.6	1.7	1.3	1.3	1.2	1.1	1.0	1.1	1.0	0.6	0.5	0.2	0.2	0.1	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2015	3.5	3.9	4.3	4.3	4.1	4.5	4.0	2.5	2.0	1.5	0.8	0.8	0.8	0.8	0.7	0.9	1.3	1.1	1.2	0.2	0.2	0.1	0.1	0.1
		JNGI2016	3.5	3.9	4.3	4.3	4.1	4.5	4.0	2.5	2.0	1.5	0.8	0.8	0.8	0.8	0.7	0.9	1.3	1.1	1.2	0.2	0.2	0.1	0.1	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	NF_3	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.8	0.9	0.9	1.0	1.2	1.4	1.1	1.2
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.8	0.9	0.9	1.0	1.2	1.4	1.1	1.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
C. Metal Production	CO_2	JNGI2015	7.3	7.1	6.8	6.7	6.7	6.8	6.9	6.8	6.5	6.5	6.7	6.8	6.6	6.4	6.5	6.5	6.6	6.7	6.2	5.5	6.1	6.0	6.1	6.3
		JNGI2016	7.3	7.1	6.8	6.7	6.7	6.8	6.9	6.8	6.5	6.5	6.7	6.8	6.6	6.4	6.5	6.5	6.6	6.7	6.2	5.5	6.1	6.0	6.1	6.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*0.00%*	*-0.01%*	*-0.01%*	*-0.02%*	*-0.08%*	*-0.15%*	*-0.19%*	*-0.20%*	*-0.21%*	*-0.26%*	*-0.68%*	*-2.08%*
	CH_4	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	HFCs	JNGI2015	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0	0.0	0.0
		JNGI2016	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.0	0.0	0.0
		difference	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*	*0.00%*	*0.00%*
	PFCs	JNGI2015	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.6	1.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.6	0.2	0.3	0.2	0.2	0.2
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.6	1.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	0.6	0.2	0.3	0.2	0.2	0.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
D. Non-energy Products from Fuels and Solvent Use	CO_2	JNGI2015	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
		JNGI2016	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*-0.26%*	*0.05%*

Table 10-3 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Industrial processes and product use sector) (2/2)

2. Industrial Processes and Product Use
(2/2) [Mt-CO_2 eq.]

Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. Electronic Industry	HFCs	JNGI2015	0.0	NO	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1
		JNGI2016	0.0	NO	0.0	0.1	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1
		difference	*0.00%*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	PFCs	JNGI2015	1.5	1.7	1.7	2.5	3.1	4.0	4.7	6.0	6.1	6.5	7.0	5.3	5.4	5.3	5.6	4.7	5.1	4.5	3.4	2.1	2.3	1.9	1.7	1.6
		JNGI2016	1.5	1.7	1.7	2.5	3.1	4.0	4.7	6.0	6.1	6.5	7.0	5.3	5.4	5.3	5.6	4.7	5.1	4.5	3.4	2.1	2.3	1.9	1.7	1.6
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2015	0.4	0.5	0.5	0.5	0.5	0.5	0.8	1.1	1.2	1.4	1.5	1.3	1.4	1.4	1.4	1.3	1.0	0.8	0.6	0.4	0.5	0.4	0.4	0.4
		JNGI2016	0.4	0.5	0.5	0.5	0.5	0.5	0.8	1.1	1.2	1.4	1.5	1.3	1.4	1.4	1.4	1.3	1.0	0.8	0.6	0.4	0.5	0.4	0.4	0.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	NF_3	JNGI2015	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.3	0.2	0.2	0.2	0.2	0.1
		JNGI2016	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.4	0.3	0.2	0.2	0.2	0.2	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
F. Product Uses as ODS Substitutes	HFCs	JNGI2015	0.0	IE,NE,NO	0.1	0.9	1.9	2.9	4.1	5.1	5.7	6.1	6.6	7.0	7.9	9.1	10.3	11.5	13.1	15.7	18.0	20.3	22.8	25.5	28.8	31.5
		JNGI2016	0.0	IE,NE,NO	0.1	0.9	1.9	2.9	4.1	5.1	5.7	6.1	6.6	7.0	7.9	9.1	10.3	11.5	13.2	15.8	18.1	20.5	23.0	25.8	29.1	31.8
		difference	*0.00%*	*NA*	*0.00%*	*0.03%*	*0.03%*	*0.03%*	*0.03%*	*0.02%*	*0.02%*	*0.04%*	*0.08%*	*0.15%*	*0.23%*	*0.30%*	*0.40%*	*0.50%*	*0.60%*	*0.66%*	*0.73%*	*0.77%*	*0.84%*	*0.88%*	*0.90%*	*0.99%*
	PFCs	JNGI2015	4.5	5.3	5.4	7.8	9.6	12.6	12.2	12.3	8.8	5.0	3.2	3.2	2.6	2.3	2.5	2.8	2.8	2.4	1.6	1.4	1.7	1.6	1.6	1.5
		JNGI2016	4.5	5.3	5.4	7.8	9.6	12.6	12.2	12.3	8.8	5.0	3.2	3.2	2.6	2.3	2.5	2.8	2.8	2.4	1.6	1.4	1.7	1.6	1.6	1.5
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
G. Other Product Manufacture and Use	N_2O	JNGI2015	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
		JNGI2016	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.06%*
	PFCs	JNGI2015	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA,NO	0.0
		JNGI2016	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	NA,NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA,NO	0.0
		difference	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*NA*	*0.00%*
	SF_6	JNGI2015	8.8	9.7	10.7	10.8	10.3	11.3	12.1	10.8	9.6	5.7	3.7	2.9	2.4	2.2	2.0	1.8	1.9	1.8	1.7	1.6	1.5	1.6	1.6	1.6
		JNGI2016	8.8	9.7	10.7	10.8	10.3	11.3	12.1	10.8	9.6	5.7	3.7	2.9	2.4	2.2	2.0	1.8	1.8	1.8	1.7	1.6	1.4	1.5	1.6	1.5
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.61%*	*-0.81%*	*-1.19%*	*-1.67%*	*-1.75%*	*-2.99%*	*-3.26%*	*-3.95%*	*-4.09%*
H. Other	CO_2	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
2. Total	GHG	JNGI2015	109.3	113.6	115.5	117.7	125.0	135.0	137.1	134.1	121.5	108.6	106.6	95.5	88.4	87.0	83.7	84.7	87.3	86.4	82.1	74.8	78.2	80.0	82.6	86.9
		JNGI2016	109.3	113.7	115.5	117.7	125.0	135.1	137.1	134.1	121.5	108.7	106.6	95.5	88.5	87.1	83.8	84.8	87.4	86.5	82.2	74.9	78.4	80.2	82.8	87.0
		difference	*0.05%*	*0.05%*	*0.01%*	*0.03%*	*0.03%*	*0.05%*	*0.01%*	*0.02%*	*0.02%*	*0.03%*	*0.04%*	*0.05%*	*0.05%*	*0.07%*	*0.09%*	*0.10%*	*0.11%*	*0.14%*	*0.17%*	*0.20%*	*0.20%*	*0.22%*	*0.17%*	*0.09%*

Table 10-4 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Agriculture sector)

3. Agriculture		[Mt-CO_2 eq.]																								
Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A. Enteric Fermentation	CH_4	JNGI2015	9.1	9.2	9.3	9.2	9.1	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.5	8.3	8.3	8.3	8.3	8.2	8.1	7.8	7.8	7.6	7.4
		JNGI2016	9.1	9.2	9.3	9.2	9.1	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.5	8.3	8.3	8.3	8.3	8.2	8.1	7.8	7.8	7.6	7.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*-0.01%*	*-0.02%*	*-0.03%*
B. Manure Management	CH_4	JNGI2015	3.4	3.4	3.3	3.3	3.2	3.1	3.1	3.1	3.0	2.9	2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.4
		JNGI2016	3.4	3.4	3.3	3.3	3.2	3.1	3.1	3.1	3.0	2.9	2.9	2.9	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.4
		difference	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.02%*	*-0.03%*	*-0.03%*	*-0.03%*	*-0.03%*	*-0.03%*	*-0.03%*	*-0.04%*	*-0.04%*
	N_2O	JNGI2015	4.2	4.3	4.3	4.2	4.1	4.0	4.0	4.0	3.9	3.9	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.7	4.6	4.7	4.6	4.5
		JNGI2016	4.2	4.3	4.3	4.2	4.1	4.0	4.0	4.0	3.9	3.9	3.9	4.0	4.1	4.2	4.2	4.3	4.4	4.5	4.6	4.7	4.6	4.7	4.6	4.5
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
C. Rice Cultivation	CH_4	JNGI2015	17.3	16.0	17.8	13.5	19.4	17.9	17.4	17.1	15.5	16.1	16.7	16.3	16.4	15.1	17.0	17.3	16.9	17.5	17.8	17.4	18.6	18.3	17.9	18.1
		JNGI2016	17.3	16.0	17.8	13.5	19.4	17.9	17.4	17.1	15.5	16.1	16.7	16.3	16.4	15.0	17.0	17.3	16.9	17.5	17.8	17.4	18.6	18.2	17.9	18.1
		difference	*0.00%*	*0.00%*	*-0.03%*	*-0.05%*	*-0.03%*	*-0.03%*	*-0.03%*	*-0.04%*	*-0.06%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.07%*	*-0.08%*	*-0.07%*	*-0.06%*	*-0.05%*	*-0.05%*	*-0.04%*	*-0.03%*	*-0.04%*	*-0.04%*	*-0.03%*	*-0.02%*
D. Agricultural Soils	N_2O	JNGI2015	8.2	8.0	7.9	8.0	7.9	7.6	7.5	7.4	7.3	7.3	7.3	7.1	7.1	7.1	7.0	6.9	6.9	7.2	6.5	6.2	6.6	6.5	6.5	6.5
		JNGI2016	7.3	7.1	7.0	7.1	7.0	6.7	6.6	6.5	6.4	6.4	6.5	6.3	6.3	6.2	6.1	6.1	6.0	6.4	5.6	5.4	5.8	5.7	5.7	5.7
		difference	*-11.35%*	*-11.29%*	*-11.28%*	*-11.10%*	*-11.20%*	*-11.58%*	*-11.79%*	*-11.86%*	*-11.88%*	*-11.84%*	*-11.72%*	*-11.96%*	*-11.93%*	*-11.97%*	*-12.11%*	*-12.14%*	*-12.18%*	*-11.60%*	*-12.88%*	*-13.40%*	*-12.60%*	*-12.68%*	*-12.70%*	*-11.35%*
F. Field Burning of Agricultural Residues	CH_4	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		difference	1.76%	1.66%	1.97%	1.88%	2.21%	2.12%	2.03%	1.99%	1.79%	1.76%	1.65%	1.54%	1.43%	1.28%	1.25%	1.37%	1.28%	1.23%	1.10%	1.07%	1.08%	1.10%	1.06%	4.20%
	N_2O	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*1.76%*	*1.66%*	*1.97%*	*1.88%*	*2.21%*	*2.12%*	*2.03%*	*1.99%*	*1.79%*	*1.76%*	*1.65%*	*1.54%*	*1.43%*	*1.28%*	*1.25%*	*1.37%*	*1.28%*	*1.23%*	*1.10%*	*1.07%*	*1.08%*	*1.10%*	*1.06%*	*4.20%*
G. Liming	CO_2	JNGI2015	0.6	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.4	0.4
		JNGI2016	0.6	0.5	0.5	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.2	0.4	0.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*2.60%*
H. Urea Application	CO_2	JNGI2015	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2
		JNGI2016	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2	0.2	0.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*3.78%*	*-7.16%*	*22.52%*
3. Total	GHG	JNGI2015	42.9	41.6	43.3	38.8	44.1	42.2	41.3	40.9	39.1	39.5	40.1	39.5	39.6	38.2	39.8	40.0	39.6	40.8	40.3	39.5	40.7	40.3	39.7	39.5
		JNGI2016	42.0	40.7	42.4	37.9	43.2	41.3	40.5	40.0	38.2	38.6	39.2	38.6	38.8	37.3	38.9	39.2	38.8	40.0	39.4	38.6	39.9	39.4	38.9	38.8
		difference	*-2.16%*	*-2.17%*	*-2.08%*	*-2.30%*	*-2.01%*	*-2.09%*	*-2.14%*	*-2.15%*	*-2.24%*	*-2.21%*	*-2.16%*	*-2.18%*	*-2.16%*	*-2.25%*	*-2.15%*	*-2.12%*	*-2.13%*	*-2.07%*	*-2.09%*	*-2.13%*	*-2.06%*	*-2.06%*	*-2.13%*	*-1.75%*

Table 10-5 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Land use, land-use change and forestry sector)

4. Land Use, Land-Use Change and Forestry

[Mt-CO_2 eq.]

Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A. Forest Land	CO_2	JNGI2015	-79.1	-86.2	-86.6	-86.9	-87.3	-87.6	-91.3	-91.1	-91.0	-90.8	-90.6	-90.5	-90.3	-99.0	-98.5	-92.7	-86.8	-85.6	-80.4	-75.5	-76.0	-77.8	-77.4	-68.2
		JNGI2016	-79.1	-86.2	-86.6	-86.9	-87.3	-87.6	-91.3	-91.1	-91.0	-90.8	-90.6	-90.5	-90.3	-99.0	-98.5	-92.7	-86.8	-85.6	-80.3	-75.5	-76.0	-77.8	-77.4	-68.2
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*
	CH_4	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	N_2O	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		difference	*-4.78%*	*-4.79%*	*-4.80%*	*-4.72%*	*-4.75%*	*-4.78%*	*-4.71%*	*-4.69%*	*-4.78%*	*-4.80%*	*-4.79%*	*-4.77%*	*-4.74%*	*-4.80%*	*-4.77%*	*-4.78%*	*-4.81%*	*-4.81%*	*-4.75%*	*-4.79%*	*-4.81%*	*-4.81%*	*-4.82%*	*-4.80%*
B. Cropland	CO_2	JNGI2015	12.2	10.9	7.5	5.6	6.4	5.6	4.0	3.3	3.3	2.2	0.2	0.1	0.4	-0.3	2.7	2.3	1.5	4.9	10.3	7.9	5.4	5.7	4.7	3.7
		JNGI2016	12.1	10.8	7.4	5.6	6.4	5.6	4.0	3.3	3.3	2.2	0.2	0.1	0.4	-0.3	2.7	2.3	1.5	4.9	10.3	7.9	5.5	5.7	4.8	3.6
		difference	*-1.07%*	*-0.67%*	*-1.07%*	*-0.50%*	*-0.42%*	*-0.47%*	*-0.50%*	*-0.49%*	*-0.55%*	*-0.75%*	*-4.10%*	*-5.47%*	*-1.51%*	*2.89%*	*-0.25%*	*-0.68%*	*1.03%*	*-0.17%*	*0.27%*	*0.00%*	*1.46%*	*0.00%*	*0.76%*	*-0.34%*
	CH_4	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	N_2O	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*-54.77%*	*-54.72%*	*-54.70%*	*-54.67%*	*-54.69%*	*-54.56%*	*-54.38%*	*-54.20%*	*-54.11%*	*-54.01%*	*-53.84%*	*-53.74%*	*-53.62%*	*-53.19%*	*-52.78%*	*-52.27%*	*-51.69%*	*-50.91%*	*-49.96%*	*-48.99%*	*-48.11%*	*-47.57%*	*-46.93%*	*-46.68%*
C. Grassland	CO_2	JNGI2015	1.1	0.9	0.1	-0.2	0.1	0.7	0.3	0.1	0.0	-0.4	0.0	-0.3	-0.5	-1.2	-0.9	-1.0	-0.5	-1.0	-1.3	-0.3	-0.2	0.2	-0.2	-0.2
		JNGI2016	1.1	0.8	0.1	-0.2	0.1	0.7	0.3	0.1	0.0	-0.4	0.0	-0.3	-0.5	-1.2	-0.9	-1.0	-0.5	-1.0	-1.3	-0.3	-0.2	0.2	-0.2	-0.2
		difference	*-1.63%*	*-1.21%*	*-8.58%*	*2.14%*	*-3.66%*	*-0.58%*	*-0.87%*	*-4.14%*	*-8.22%*	*0.66%*	*-2.97%*	*0.37%*	*0.18%*	*0.09%*	*0.11%*	*0.61%*	*1.84%*	*0.35%*	*0.46%*	*-0.07%*	*2.94%*	*-0.06%*	*2.77%*	*3.17%*
	CH_4	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.00%*	*0.00%*	*0.00%*
	N_2O	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*	*-58.18%*
D. Wetlands	CO_2	JNGI2015	0.1	0.1	0.3	0.1	0.1	0.4	0.6	0.1	0.5	0.5	0.4	0.4	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0
		JNGI2016	0.1	0.1	0.2	0.1	0.1	0.3	0.6	0.1	0.5	0.4	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0
		difference	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*-6.20%*	*30.05%*	*-6.20%*	*22.44%*	*0.00%*	*29.32%*	*0.00%*	*21.13%*	*-8.45%*
E. Settlements	CO_2	JNGI2015	4.2	5.1	5.7	3.6	2.5	2.3	1.5	1.0	1.0	0.5	0.1	-0.2	-1.1	-1.2	-1.2	-0.5	-0.3	-1.3	-0.7	-0.5	0.0	-1.0	-0.7	-0.9
		JNGI2016	3.9	4.7	5.2	3.3	2.2	2.0	1.2	0.8	0.8	0.3	-0.1	-0.3	-1.2	-1.3	-1.3	-0.6	-0.5	-1.4	-0.7	-0.5	0.2	-1.1	-0.7	-1.0
		difference	*-9.02%*	*-8.61%*	*-8.44%*	*-9.86%*	*-11.78%*	*-12.33%*	*-16.05%*	*-20.62%*	*-21.98%*	*-36.59%*	*-180.34%*	*84.99%*	*8.95%*	*7.70%*	*7.77%*	*29.05%*	*81.10%*	*7.24%*	*8.08%*	*7.06%*	*965.32%*	*3.30%*	*3.95%*	*13.73%*
F. Other Land	CO_2	JNGI2015	1.5	1.7	1.4	1.7	1.5	1.3	1.2	1.6	1.2	1.3	1.0	1.0	0.9	0.8	0.8	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.1	0.1
		JNGI2016	1.5	1.6	1.3	1.6	1.4	1.2	1.1	1.5	1.1	1.2	0.9	1.0	0.9	0.7	0.7	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1
		difference	*-5.79%*	*-5.83%*	*-5.73%*	*-5.78%*	*-5.74%*	*-5.69%*	*-5.66%*	*-5.81%*	*-5.69%*	*-5.74%*	*-5.58%*	*-5.62%*	*-5.60%*	*-5.50%*	*-5.50%*	*-3.03%*	*5.32%*	*-2.19%*	*7.80%*	*0.08%*	*17.78%*	*0.34%*	*9.14%*	*-4.07%*
	N_2O	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.08%*	*0.09%*	*0.17%*	*0.19%*	*0.74%*	*0.82%*	*1.05%*	*1.18%*
G. Harvested Wood Products	CO_2	JNGI2015	0.9	0.5	2.0	2.5	3.8	2.9	4.6	2.6	1.4	2.6	2.2	2.5	2.0	2.9	1.8	1.7	1.4	0.2	0.2	1.3	0.9	3.3	0.3	0.6
		JNGI2016	0.9	0.4	1.9	2.3	3.7	2.8	4.4	2.5	1.4	2.6	2.1	2.4	1.9	2.8	1.7	1.6	1.3	0.2	0.2	1.3	0.9	3.3	0.5	0.4
		difference	*-9.51%*	*-20.67%*	*-6.17%*	*-4.85%*	*-2.83%*	*-3.56%*	*-3.47%*	*-4.36%*	*-4.64%*	*-2.73%*	*-4.21%*	*-3.10%*	*-4.24%*	*-3.37%*	*-4.54%*	*-4.24%*	*-3.66%*	*-15.81%*	*-33.36%*	*-0.69%*	*-3.12%*	*-1.19%*	*57.13%*	*-34.35%*
(IV) Indirect N_2O emissions from managed soils	N_2O	JNGI2015	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*-27.27%*	*-26.70%*	*-26.36%*	*-25.92%*	*-25.66%*	*-24.61%*	*-23.34%*	*-22.18%*	*-21.69%*	*-21.23%*	*-20.64%*	*-20.23%*	*-19.83%*	*-18.81%*	*-17.94%*	*-17.06%*	*-16.19%*	*-15.23%*	*-14.32%*	*-13.52%*	*-12.89%*	*-12.56%*	*-12.22%*	*-12.05%*
4. Total	GHG	JNGI2015	-58.5	-66.6	-69.2	-73.2	-72.5	-74.1	-78.7	-82.0	-83.2	-83.7	-86.4	-86.6	-88.2	-97.7	-95.1	-89.6	-84.2	-82.3	-71.4	-66.6	-69.4	-69.2	-72.8	-64.7
		JNGI2016	-59.3	-67.5	-70.1	-73.9	-73.1	-74.7	-79.3	-82.6	-83.7	-84.2	-86.8	-86.9	-88.5	-98.0	-95.4	-89.9	-84.4	-82.5	-71.5	-66.6	-69.1	-69.3	-72.6	-65.0
		difference	*1.39%*	*1.25%*	*1.28%*	*0.97%*	*0.84%*	*0.81%*	*0.77%*	*0.63%*	*0.57%*	*0.54%*	*0.48%*	*0.44%*	*0.35%*	*0.31%*	*0.30%*	*0.33%*	*0.33%*	*0.22%*	*0.17%*	*0.12%*	*-0.35%*	*0.16%*	*-0.22%*	*0.60%*

Table 10-6 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 (Waste sector)

5. Waste		[Mt-CO_2 eq.]																								
Category	Gas		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
A. Solid Waste Disposal	CH_4	JNGI2015	9.2	9.2	9.1	9.0	8.9	8.6	8.4	8.1	7.8	7.5	7.2	6.9	6.6	6.3	6.0	5.7	5.4	5.1	4.7	4.4	4.1	3.9	3.7	3.5
		JNGI2016	9.2	9.2	9.1	9.0	8.9	8.6	8.4	8.1	7.8	7.5	7.2	6.9	6.6	6.3	6.0	5.7	5.4	5.1	4.7	4.4	4.1	3.9	3.7	3.5
		difference	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*-0.02%*	*-0.03%*	*-0.04%*	*-0.06%*	*-0.06%*	*-0.05%*	*-0.04%*	*-0.04%*	*-0.03%*	*-0.02%*	*-0.02%*	*-0.01%*	*-0.01%*	*0.01%*	*-0.24%*	*-0.19%*	*-0.16%*	*-0.13%*	*-0.07%*	*-0.13%*
B. Biological Treatment of Solid Waste	CH_4	JNGI2015	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.20	0.25	0.29	0.30	0.34	0.35	0.34	0.38	0.38	0.33	0.36	0.36	0.36
		JNGI2016	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.20	0.25	0.29	0.30	0.34	0.35	0.34	0.38	0.38	0.33	0.36	0.36	0.36
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.08%*	*-1.23%*
	N_2O	JNGI2015	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.18	0.21	0.21	0.24	0.25	0.24	0.27	0.27	0.24	0.26	0.26	0.26
		JNGI2016	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.18	0.21	0.21	0.24	0.25	0.24	0.27	0.27	0.24	0.26	0.26	0.25
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.08%*	*-1.23%*
C. Incineration and Open Burning of Waste	CO_2	JNGI2015	12.4	12.5	13.5	13.3	15.8	16.0	16.5	17.1	17.1	16.8	17.0	15.8	15.2	15.2	14.6	14.1	13.2	13.1	14.7	12.0	12.5	12.1	12.6	12.8
		JNGI2016	12.4	12.5	13.5	13.3	15.8	16.0	16.5	17.1	17.1	16.8	17.0	15.8	15.2	15.2	14.6	14.1	13.2	13.1	14.7	12.0	12.5	11.9	12.5	12.3
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*-0.05%*	*0.01%*	*-0.01%*	*-0.01%*	*-0.04%*	*-0.97%*	*-1.01%*	*-3.43%*
	CH_4	JNGI2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		JNGI2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.34%*	*1.09%*
	N_2O	JNGI2015	1.4	1.5	1.6	1.6	1.8	1.9	2.0	2.1	2.1	2.2	2.2	2.1	1.9	1.9	1.9	2.0	1.8	1.7	1.6	1.6	1.5	1.5	1.6	1.6
		JNGI2016	1.4	1.5	1.6	1.6	1.8	1.9	2.0	2.1	2.1	2.2	2.2	2.1	1.9	1.9	1.9	2.0	1.8	1.7	1.6	1.6	1.5	1.5	1.5	1.5
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-2.07%*	*-1.64%*
D. Waste Water Treatment and Discharge	CH_4	JNGI2015	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.4	2.2	2.1	2.1	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7
		JNGI2016	2.9	2.8	2.8	2.7	2.7	2.6	2.6	2.6	2.5	2.5	2.4	2.2	2.1	2.1	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.8	1.7	1.7
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*0.00%*	*0.00%*	*0.00%*	*-0.19%*	*-0.01%*	*-0.18%*
	N_2O	JNGI2015	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
		JNGI2016	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.11%*	*0.00%*	*-0.12%*
E. Other	CO_2	JNGI2015	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.6	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5
		JNGI2016	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.6	0.7	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.6
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*2.53%*	*10.62%*
5. Total	GHG	JNGI2015	28.2	28.1	29.3	28.8	31.3	31.5	31.7	32.1	31.7	31.2	31.0	29.2	28.1	27.8	26.9	26.1	24.8	24.1	25.4	22.2	22.3	21.5	21.9	21.8
		JNGI2016	28.2	28.1	29.3	28.8	31.3	31.5	31.7	32.1	31.7	31.2	31.0	29.2	28.1	27.8	26.9	26.1	24.8	24.1	25.4	22.2	22.3	21.4	21.7	21.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*0.00%*	*-0.03%*	*-0.03%*	*0.01%*	*-0.05%*	*-0.04%*	*-0.05%*	*-0.59%*	*-0.68%*	*-1.93%*

10.2.2. KP-LULUCF Inventory

Compared to the values reported in the previous year's inventory, total emissions/removals arising from KP-LULUCF activities in 2013 increased by 1.31% (Table 10-7).

Table 10-7 Comparison of emissions and removals in the inventories submitted in 2015 and 2016 for KP-LULUCF activities

KP-LULUCF activities		[Mt-CO_2 eq.]		
Activity	Gas		1990	2013
Afforestation and Reforestation	CO_2	JNGI2015	-	-0.49
		JNGI2016	-	-0.53
		difference	-	*8.21%*
	CH_4	JNGI2015	-	0.00001
		JNGI2016	-	0.00001
		difference	-	*8.46%*
	N_2O	JNGI2015	-	0.000000
		JNGI2016	-	0.000000
		difference	-	*8.46%*
Deforestation	CO_2	JNGI2015	-	1.6
		JNGI2016	-	1.5
		difference	-	*-10.41%*
	N_2O	JNGI2015	-	0.02
		JNGI2016	-	0.02
		difference	-	*4.37%*
Forest Management	CO_2	JNGI2015	-	-50.8
		JNGI2016	-	-51.2
		difference	-	*0.71%*
	CH_4	JNGI2015	-	0.003
		JNGI2016	-	0.003
		difference	-	*-1.61%*
	N_2O	JNGI2015	-	0.1
		JNGI2016	-	0.1
		difference	-	*-4.77%*
Cropland Management	CO_2	JNGI2015	10.1	3.5
		JNGI2016	10.1	3.5
		difference	*0%*	*0%*
	CH_4	JNGI2015	0.1	0.1
		JNGI2016	0.1	0.1
		difference	*0%*	*0%*
	N_2O	JNGI2015	0.1	0.03
		JNGI2016	0.1	0.02
		difference	*-55.27%*	*-48.01%*
Grazing Land Management	CO_2	JNGI2015	0.8	-0.3
		JNGI2016	0.8	-0.3
		difference	*0%*	*0%*
	CH_4	JNGI2015	0.002	0.002
		JNGI2016	0.002	0.002
		difference	*0.0000%*	*-0.0012%*
	N_2O	JNGI2015	0.013	0.012
		JNGI2016	0.005	0.005
		difference	*-58.18%*	*-58.18%*
Revegetation	CO_2	JNGI2015	-0.1	-1.2
		JNGI2016	-0.1	-1.2
		difference	*1.35%*	*1.72%*
Total		JNGI2015	11.1	-47.4
		JNGI2016	11.0	-48.1
		difference	*-0.82%*	*1.31%*

10.3. Implication for Emission Trends, including Time Series Consistency

Table 10-8 shows the changes made to the emission trends due to the recalculations indicated in "Section 10.1. Explanation and Justification for Recalculations". The comparison between the 2015 submission (JNGI 2015) and the 2016 submission (JNGI 2016) is made through the comparison of values between FY1990 and FY2013.

10.3.1. GHG Inventory

The change between 1990 and 2013 total emissions excluding the LULUCF sector in the 2016 submission decreased by approximately 0.4 million tonnes (in CO_2 equivalents) and decreased by 0.03 percentage points, compared to the data reported in the previous submission.

Table 10-8 Comparison of change between 1990 and 2013 total emissions excluding the LULUCF sector, between the inventories submitted in 2015 and 2016

	Emissions (2013) - Emissions (1990) [Mt-CO_2 eq.]			Emissions (2013) / Emissions (1990) - 1 [%]		
	JNGI2015	JNGI2016	Difference	JNGI2015	JNGI2016	Difference
CO_2	156.3	155.5	-0.8	13.5%	13.5%	-0.1%
CH_4	-12.5	-12.5	0.03	-25.8%	-25.8%	0.1%
N_2O	-9.4	-9.3	0.1	-29.6%	-30.3%	-0.7%
HFCs	15.8	16.2	0.3	99.4%	101.4%	2.0%
PFCs	-3.3	-3.3	0	-49.8%	-49.8%	0%
SF_6	-10.7	-10.7	-0.1	-83.1%	-83.6%	-0.5%
NF_3	1.3	1.3	0	4038.1%	4038.1%	0%
Total	137.5	137.1	-0.4	10.8%	10.8%	-0.03%

10.4. Recalculations and improvement plan, including response to the review process

10.4.1. Improvements after submission of the inventory

The major improvements carried out since the submission of the 2015 inventory are listed below.

10.4.1.1. Methodology for estimating emissions and removals of GHGs

Changed calculation methods are provided in Table 10-9.

10.4.1.1.a. GHG Inventory

Table 10-9 Changes in estimation methods

Sector and category		Changes in estimation methods
1.A.2/ 1.A.4	Manufacturing industries and construction Other sector	The CH_4 and N_2O emissions in FY1990-2013 were recalculated with an establishment of the estimation method of the emissions from mobile combustion source such as off-road vehicles and other machinery.
1.A.3.b	CH_4 and N_2O emissions from road transportation	Hybrid vehicles are considered to the emission estimation of gasoline passenger vehicles. For gasoline light passenger vehicles, gasoline passenger vehicles, diesel passenger vehicles and diesel regular cargo trucks, new measurements of raw emission factors for the vehicles in response to the current regulations for exhaust gas (including vehicles with idle reduction) were provided by JAMA, and emission factors since FY2005 were revised. In addition, in order to ensure the methodological consistency with CO_2, annual distance traveled was revised from the *Statistical Yearbook of Motor Vehicle Transport* basis to the *Statistical Yearbook of Motor Vehicle Fuel Consumption* basis. Therefore, the CH_4 and N_2O emissions from road transportation (excluding motorcycles) for the period of FY1990-FY2013 were recalculated. The CH_4 and N_2O emissions from motorcycles for the period of FY1999-FY2013 were recalculated due to an update of emission factors for light two-wheel vehicles in response to the regulations for exhaust gas.
2.B.8	Methanol production	CO_2 emissions were newly estimated. The CH_4 EF was also revised.
2.B.8	Hydrogen production	CO_2 emissions were newly estimated.
2.F.1	Refrigeration and air conditioning equipment	HFC emissions from railway and vessel refrigeration and air conditioning equipment were newly estimated.
3.B.1.	Manure Management/ Cattle	Since emission factors for “pasture range and paddock” of dairy cattle and non-dairy cattle were updated, CH_4 emissions for all years were revised.
3.D.a.1	Agricultural Soils/ Direct Emissions/ Inorganic N Fertilizer	Since emission factors for synthetic fertilizer with nitrification inhibitor were developed, emissions from FY1996 to FY2013 were revised.
3.D.a.3	Agricultural Soils/ Direct Emissions/ Urine and dung deposited by grazing animals	Since emission factors for “pasture range and paddock” of dairy cattle and non-dairy cattle were updated, N_2O emissions for all years were revised.
3.D.a.5	Agricultural Soils/ Direct Emissions/ Mineralization	Since emission factor was updated, emissions for all years were revised.
4.A.1.	Forest land remaining Forest land	Due to revision of areas of afforestation and reforestation (AR areas), areas of forest land converted from other land-use categories were recalculated. Accordingly, areas of forest land remaining forest land and carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were recalculated.
4.A.2.	Land converted to Forest land	Areas of forest land converted from other land-use categories was revised. Accordingly, stocking volume of afforestation and reforestation (AR areas) and carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were recalculated.
4.B.1.	Cropland remaining Cropland	Due to recalculation in areas of cropland converted from forestland, areas of cropland remaining cropland and carbon stock changes in organic soils were also recalculated (FY2008-2013).
4.B.2.	Land converted to Cropland	Areas of cropland converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated.
4.C.1.	Grassland remaining Grassland	Due to recalculation in areas of grassland converted from forestland, areas of grassland remaining grassland and carbon stock changes in organic soils were also recalculated (FY2008-2013).
4.C.2.	Land converted to Grassland	Areas of grassland converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living

Sector and category		Changes in estimation methods
		biomass and dead organic matter in this category were recalculated (FY2008-2013).
4.D.1.	Wetlands remaining Wetlands	Due to recalculation in areas of wetlands converted from forestland, areas of wetlands remaining wetlands were also recalculated (FY2008-2013).
4.D.2.	Land converted to Wetlands	Areas of wetlands converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated.
4.E.1.	Settlements remaining Settlements	Due to recalculation in areas of Settlements converted from forestland, areas of Settlements remaining Settlements and carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were also recalculated.
4.E.1.	Settlements remaining Settlements	Due to revision of parameter of carbon soil changes, carbon stock changes in mineral soils were recalculated (FY1990-2013).
4.E.2.	Land converted to Settlements	Areas of Settlements converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013), dead organic matter and mineral soils (FY2008-2013) in this category were recalculated.
4.F.2.	Land converted to Other lands	Areas of Other land converted from forest land and stocking volume of deforestation (D areas) were recalculated due to revision of areas of deforestation (D area). Accordingly, carbon stock changes in living biomass (FY1990-2013) and dead organic matter (FY2008-2013) in this category were recalculated.
5.C.1	Incineration and Open Burning of Waste	Identifying the additional uses of biomass-based plastics products, CO_2 emission estimates were recalculated.
1.A.	Waste Incineration and Energy Use (Reported on Energy Sector)	Re-examining the activity data for waste oil as alternative fuels, emission estimates were recalculated.

10.4.1.1.b. KP-LULUCF Inventory

Table 10-10 Changes in estimation methods

Sector and category	Changes in estimation methods
Afforestation (A), Reforestation (R), Deforestation (D)	AR areas and D areas were recalculated due to revision of ARD identification results used for estimating the areas. As a result, carbon stock changes in all carbon pools under the ARD activities for FY2013 were recalculated.
Forest Management (FM)	Carbon stock changes in all carbon pools under the FM activities for FY 2013 were recalculated due to revision of ARD areas mention above. Since the amount of loss of soil carbon of N mineralized in FM have been revised, N_2O emissions from N mineralization associated with loss of soil organic matter in FM for FY 2013 were recalculated. In addition, carbon stock change in HWP for FY 2013 was recalculated due to the revision of activity data used.
Cropland Management (CM)	Since the emission factor had been updated, N_2O emissions from mineral soil in CM were recalculated for FY1990 and FY2013.
Grazing Land Management (GM)	Since the emissions factor had been updated, N_2O emissions from mineral soil in CM were recalculated for FY1990 and FY2013.
Revegetation (RV)	RV areas were recalculated because D areas and correspondent Article 3.4 areas which subject to both D and RV activities were recalculated due to the revision of AR areas and D areas. As a result, carbon stock changes in all carbon pools in RV for FY 1990 and FY 2013 were also recalculated. In addition, carbon stock changes in soil in RV for FY 1990 and FY 2013 were calculated because carbon stock in soil per unit area in urban parks was revised.

10.4.1.2. National Greenhouse Gas Inventory Report

No major changes since the previous submission.

10.4.1.3. Improvements by following UNFCCC-ERT recommendations

Actions taken in response to recommendations from UNFCCC review are summarized below. See relative sections for details.

The Committee for Greenhouse Gas Estimation Methods (see "Committee for Greenhouse Gas Estimation Methods" (Chapter 1.2.1.2.) address all the recommendations raised by ERT, and efforts have been made to tackle the issues and improve the national GHG inventory with due consideration of the priority.

Table 10-11 Summary of improvements made to the national inventory in response to recommendations from UNFCCC review

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Energy/ non-energy use of fuels (1.A)	Provide a table in the NIR mapping the various types of fuels as reported in the energy balance with the corresponding fuels as reported in CRF table 1.A(d) (ARR 2014 para. 31)	The table was included in this NIR.	NIR Annex 4 (A4.2.2)
Energy/ Coal mining and handling (1.B.1.a.ii)	Provide, in the NIR, justification on the mean value of the default range regarding fugitive CH_4 emissions from mining activities in surface mines (ARR 2014 para. 41)	The explanation was included in this NIR.	NIR Chapter 3 (3.2.1.1.b)
Energy/ Other transportation (1.A.3.e)	Report emissions from pipeline transport as "NO" and provide explanations in the NIR (ARR 2014 para. 44)	The emissions were reported as "NO" and the explanation was included in this NIR.	NIR Chapter 3 (3.2.9.5)
Energy/ fugitive emissions from oil production (1.B.2.a.ii)	Include, in the NIR, an explanation on condensate and light crude oil, in particular the exact definition of each product and the quantities produced in 2012 (ARR 2014 para. 49)	The explanation was included in this NIR.	NIR Chapter 3 (3.2.2.1.b)
Energy/ international bunker fuels (1.D)	Report the emissions from the oxidation of fuels used as lubricants (ARR 2012 para. 41)	The emissions were estimated.	CRF table 1.D
LULUCF Forest land remaining Forest land(4.A.1)	Provide an information to support the reason for using the notation key "NA" in carbon stock changes in bamboo forest (ARR 2014 paragraph 77)	The explanation was added in the NIR	NIR Chapter 6 (6.5.1.a))
Revegetation (4KP)	Report why a reported decrease in removals per unit area occurred between 2008 and 2012(ARR 2014 paragraph 107).	The explanation was added in the NIR.	NIR Chapter 11 (11.5.1.1)

10.4.2. Planned Improvements

The following improvements are continuously performed and reflect in an inventory preparation process accordingly. See relative sections for details.

1. Review of estimation methods, activity data, emission factors and other elements

   Japan holds meetings of a Committee for Greenhouse Gas Emission Estimation Methods and considers improvements of estimation methods, activity data, emission factors and other elements used in the current inventory. In case of implementation, Japan prioritizes highly important issues such as those relevant to key-categories and those pointed out in the past review reports.

2. Improvement of transparency

   Japan will further improve transparency of the inventory by examining descriptions of methodologies, assumptions, data, and other elements in NIR, and by adding necessary information to NIR.

Chapter 11. Supplementary Information on LULUCF activities under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol

11.1. Summary of removal related trends, and emissions and removals from KP LULUCF activities

In accordance with the decision 2/CMP.8 in paragraph 4 adopted by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (COP/MOP8), Japan reports afforestation/reforestation (AR), deforestation (D), forest management (FM), cropland management (CM), grazing land management (GM) and revegetation (RV) as LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol for the second commitment period. Table 11-1 shows the activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4. The net removals in FY2014 by those activities were 45,417 kt-CO_2 eq. (Table 11-2). Methodological tiers used are shown in Table 11-3.

Table 11-1 Activity coverage and other information relating to activities under Article 3.3 and elected activities under Article 3.4 (CRF-Table NIR 1)

Activity		Change in carbon pool reported							Greenhouse gas sources reported							
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil		HWP	Fertilization	Drained, rewetted and other soils		Nitrogen mineralization in mineral soils	Indirect N_2O emissions from managed soil	Biomass burning		
						Mineral	Organic		N_2O	CH_4	N_2O	N_2O	N2O	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and reforestation	R	R	R	R	R	NO	NO	IE	NO	NO	NA	R	IE	R	R
	Deforestation	R	R	R	R	R	NO	IO	IE	NO	NO	R	R	NO	NO	NO
Article 3.4 activities	Forest management	R	R	R	R	R	NO	R	R	NO	NO	R	R	IE	R	R
	Cropland management	R	R	NR	NR	R	R			R		R		IE	R	R
	Grazing land management	R	R	NR	NR	R	R			R		R		NO	NO	NO
	Revegetation	R	R	R	IE	R	NO		IE	NO	NO	NA	NO	NO	NO	NO
	Wetland drainage and rewetting	NA	NA	NA	NA	NA	NA		NA	NA	NA		NA	NA	NA	NA

*R: Reported; NR: Not reported; IO: Instantaneous oxidation;
See annex 5 for the definitions of the other notation keys.

Table 11-2 Accounting summary for activities under Articles 3.3 and 3.4 of the Kyoto Protocol (CRF Accounting table)

Greenhouse gas source and sink activities	Net Emissions/removals [kt CO_2 eq.]		
	1990（Base Year）	2013	2014
A. Article 3.3 activities			
A.1. Afforestation/reforestation		-532	-531
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
A.2. Deforestation		1,493	2,134
B. Article 3.4 activities			
B.1. Forest management			
Net emissions/removals		-51,070	-50,033
Excluded emissions from natural disturbances		NA	NA
Excluded subsequent removals from land subject to natural disturbances		NA	NA
Any debits from newly established forest (CEF-ne)		NA	NA
Forest management reference level (FMRL)		0	0
Technical corrections to FMRL		1,268	1,489
Forest management cap			
B.2. Cropland management	10,262	3,554	4,328
B.3. Grazing land management	841	-300	-90
B.4. Revegetation	-79	-1,206	-1,225
B.5. Wetland drainage and rewetting (not elected)	NA	NA	NA

* The total values and results of summing up each figure are not always the same because of the difference in display digit.

Table 11-3 Methodological tiers used

Activity		CO_2		CH_4		N_2O	
		Method applied	Emission factor	Method applied	Emission factor	Method applied	Emission factor
Article 3.3 activities	Afforestation and reforestation	T2	CS	T1	D	T1	D
	Deforestation	T2	CS,D			T1	CS,D
Article 3.4 activities	Forest management	T2,T3	CS,D	T1	D	T1,T2	CS,D
	Cropland management	T2,T3	CS,D	T1	CS,D	T1,CS	CS,D
	Grazing land management	T2,T3	CS,D	T1	CS,D	CS	CS
	Revegetation	T2	CS,D				
	Wetland drainage and rewetting						

D: IPCC default, T1: IPCC Tier1, T2: IPCC Tier2, T3: IPCC Tier3, CS: country-specific method or emissions factor

11.2. Information relating to the decision 3/CMP.11 in paragraph 8

In reporting LULUCF activities under Article 3, paragraphs 4 of the Kyoto Protocol for the second commitment period, in order to clarify estimations and reporting method during the period, Japan describes information relating to LULUCF which has been identified in decision 3/CMP.11 in paragraph 8, as follows:

- Japan reports CM and GM as new activities under Article 3, paragraph 4, of the Kyoto Protocol, in addition to FM which became mandatory in the second commitment period, and RV which was elected in the first commitment period.
- For the FM and the RV, the methodology on land identification, which was applied to the first commitment period, has been also applied to the second commitment period; land that has been accounted for the first commitment period is also included in the second commitment period. Regarding the CM and the GM, the lands are identified based on statistics which is applied for reporting of LULUCF under the Convention. Detailed information is described in relevant sections of each activity.

11.3. General information

11.3.1. Definition of forest and any other criteria

Japan's definitions of forest are identified as the following, in accordance with decision 16/CMP.1, paragraph 20 of the annex to decision 2/CMP.7 and the requirement from *the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*.

- Minimum value for forest area: 0.3 [ha]
- Minimum value for tree crown cover: 30 [%]
- Minimum value for tree height: 5 [m]
- Minimum value for forest width: 20 [m]

Forests with minimum values for forest area, tree crown cover and forest width (mentioned above) are consistent with forests under the existing forest planning system in Japan. Although any minimum

value for tree height is not defined under the existing system, forests with usual composition of tree species and under usual climate conditions in Japan usually reach a tree height of 5 m at maturity *in situ*. Each prefecture has surveyed and compiled information on forest resources under the forest planning system into Forest Registers, which are primarily intended to be prepared for establishing forest plans. Therefore, forests under the forest planning system are considered as forests under the Kyoto Protocol, and Forest Registers are suitable as basic data source for reporting. This is the same concept as the one used for reporting the LULUCF forest sector under the Convention. The definitions of forest used for the second commitment period are the same as the first commitment period.

The definitions of forest mentioned above are consistent with those in the Global Forest Resources Assessment 2005 (FRA2005) by the Food and Agriculture Organization of the United Nation (FAO) (Table 11-4).

Table 11-4 Japan's forest categories and definition used in reporting to FAO

Category		Definition
Forest		Land on which trees and/or bamboo grow collectively, together with those trees and bamboo, or any other land that is provided for collective growth of trees and/or bamboo which are 0.3 ha or more. Lands that are utilized mainly for agriculture, residential use or other similar purposes, and trees and bamboo on these lands, are not included.
	Forest with standing trees	Forest that has a tree crown cover of 30 percent or higher (including young stands with the degree of stocking of 3 or higher).
	Forest with less standing trees (Cut-over forest, lesser stocked forest)	Forest that does not fall under "forest with standing trees" or "bamboo forest".
	Bamboo forest	Forest that does not fall under "forest with standing trees" and is mainly dominated by bamboo (excluding bamboo grass).

* See section 6.2. for a more detailed definition of each category

Before 1995, Japan classified forests with standing trees into two sub-categories, "intensively managed forests" and "semi-natural forests" in the Forestry Status Survey. Since 2002, Japan has introduced new sub-categories which are "ikusei-rin forest" and "tennensei-rin forest". In these new sub-categories, the degree of human-induced activities and stratification of forest have been taken into account. In ikusei-rin forests, intensively managed forests regenerated mainly by planting after felling and semi-natural forests regenerated by supplementary works such as site preparation are included. The definitions of intensively managed forest, semi-natural forest, ikusei-rin forest and tennensei-rin forest are shown below.

Table 11-5 Definitions of intensively managed forest, semi-natural forest, ikusei-rin forest and tennensei-rin forest[1]

Sub-categories by regeneration method		Sub-categories by management types	
Intensively managed forest	Forest regenerated by planting and so on.	Ikusei-rin Forest	Forest where practices for establishment and maintenance of single-storied forests have been carried out after clear-cutting ("ikusei-tansou-rin"), or forest where practices for establishment and maintenance of multi-storied forests have been carried out after selective cutting ("ikusei-fukusou-rin").
Semi-natural forest	Forest which is not classified as intensively managed forest.	Tennensei-rin forest	Forest where practices for establishment and maintenance of forest mainly depending on natural power are carried out.

11.3.2. Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

Japan elected FM, CM, GM and RV defined by decision 2/CMP.7 in paragraph 6 and 7 of the annex, as "additional human-induced activities related to changes in GHG emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories" defined by Article 3, paragraph 4 of the Kyoto Protocol.

Japan interprets the definition of elected activities as follows by recalling *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* which the party shall apply in accordance with decision 6/CMP.9, paragraph 9.

11.3.2.1. Forest Management

FM is defined in paragraph 1 (f) of the annex to decision 16/CMP.1 as "a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner". Japan interprets the definition of FM as the following.

- Activities for FM in ikusei-rin forests are appropriate forest practices including regeneration (land preparation, soil scarification, planting, etc.), tending (weeding, pre-commercial cutting, etc.), thinning and harvesting which have been carried out since 1990.
- Activities for FM in tennensei-rin forests are practices for protection or conservation of forests including controlling logging activities and land-use change which have been carried out by law.

11.3.2.2. Cropland Management

CM is defined in paragraph 1 (g) of the annex to decision 16/CMP.1 as "a system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production". Japan interprets the definition of CM as follows:

- Practices for cultivating in rice fields, upland fields and orchard[2]

[1] Explanations for Ikusei-rin forest and Tennensei-rin forest have been changed in accordance with the revision of the "Basic Plan for Forest and Forestry". However, the coverage of those forests remains the same.

[2] Cultivation abandoned agricultural land which is included in cropland for reporting of LULUCF under the Convention, is not included in the CM because appropriate management have not been carried out in cultivation abandoned agricultural land.

11.3.2.3. Grazing Land Management

GM is defined in paragraph 1 (h) of the annex to decision 16/CMP.1 as "a system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced". Japan interprets the definition of GM as follows:

- Practices for meadow and grazing in pasture land[3]

11.3.2.4. Revegetation

RV is defined in paragraph 1 (e) of the annex to decision 16/CMP.1 as "a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 ha and does not meet the definitions of AR". Japan interprets the definition of RV as follows:

- Practices for the creation of "parks and green space", "public green space", and "private green space guaranteed by administration" which have been carried out in settlements since 1990[4]. Activities which cover less than an area of 0.05 ha or meet the definitions of AR are not included.

11.3.3. Description of how the definitions of each activity under Article 3.3 and each elected activity under Article 3.4 have been implemented and applied consistently over time

The forest definition explained in section 11.3.1 has not changed over time. The same forest definition is used for AR and D under Article 3.3 as well as FM under Article 3.4. The definitions of FM, CM, GM and RV explained in section 11.3.2 above have been implemented and applied consistently over time.

11.3.4. Description of precedence conditions and/or hierarchy among elected Article 3.4 activities, and how they have been consistently applied in determining how land was classified

Japan interprets that FM activities occur only in forest land, and CM, GM, and RV activities occur only in non-forest land (cropland, grassland and settlements). Therefore, there is no overlap between FM and non FM activities (CM, GM, and RV).

There is a possibility that overlap may occur between CM, GM and RV when new planting is implemented in settlements converted from cropland and pasture land. In this case, the carbon stock changes are calculated in RV.

In the land conversion between CM and GM, the emissions/removals are reported under CM and GM respectively in accordance with current land use.

11.4. Land-related information

11.4.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3

In accordance with the definition of forest explained in section 11.3.1, Japan determines the spatial

[3] As for grazed meadow and wild land that are included in grassland for reporting of LULUCF under the Convention, they are not included in GM because management practices changes have not been occurred in grazed meadow and wild land is not for use of grazing.

[4] In Japan, the urban green facilities subject to RV activities are: "urban parks", "green areas on roads", "green areas at ports", "green areas around sewage treatment facilities", "green areas by greenery promoting systems for private green space", "green areas along rivers and erosion control sites", "green areas around government buildings", and "green areas around public rental housing".

assessment unit used for determining the area of the units of land under Article 3.3 as 0.3 ha.

11.4.2. Methodology used to develop the land transition matrix

11.4.2.1. Description of land transition matrix (CRF-NIR Table 2)

Table 11-6 shows the land transition matrix related to the activities under Articles 3.3 and 3.4 of the Kyoto Protocol. The FM area in Japan is estimated by using the narrow approach concept described in section 2.7.1 of the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. Therefore, new FM areas are identified every year due to the progress of FM practices in managed forests which previously had not been categorized as FM area. These areas appear as land transition from "other" to FM in Table 11-6. In a similar fashion, sites where RV practices have been newly performed become new RV areas and appear as land transition from "other" to RV in Table 11-6.

Regarding CM and GM, Japan basically estimates emissions/removals for current cropland (except for cultivation abandoned agricultural land) and current grazing land respectively; in accordance with paragraph 24 of the annex to the decision 2/CMP.7, cropland and pasture land converted to other land-use since 2013, were also included in CM and in GM.

Therefore, in addition to area change caused by new creation of cropland and grazing land, land area due to conversion of forest land into the new construction of cropland or pasture land are represented as "Deforestation", plantations area in land converted from cropland or pasture land are indicated as "Afforestation and Reforestation" in the land matrix. The land conversion across CM and GM, which has been calculated by modeling, is reported as "IE" because the changed area cannot be isolated explicitly from the previous year. In case that cropland or grassland is converted to settlements and new planting is implemented in settlements, the area is reported as RV land.

As for the values of 2014 in the land matrix, changes from reported figures in 2013, are reported.

Table 11-6 Land transition matrix of Kyoto Protocol activities (CRF-Table NIR 2)

FROM 2013 \ TO 2014		Article 3.3 activities		Article 3.4 activities					Other	Total area at the end of the previous inventory year
		Afforestation and reforestation	Deforestation	Forest management	Cropland management (if elected)	Grazing land management (if elected)	Revegetation (if elected)	Wetland drainage and rewetting (if elected)		
		(kha)								
Article 3.3 activities	Afforestation and Reforestation	35.32	NO							35.32
	Deforestation		350.80							350.80
Article 3.4 activities	Forest management		4.68	15,559.54						15,564.22
	Cropland management	0.07		NA	3,904.33	IE	0.40	NA		3,904.80
	Grazing land management	0.01		NA	IE	608.15	0.13	NA		608.29
	Revegetation	NO		NA	NA	NA	81.64	NA		81.64
	Wetland drainage and rewetting (if elected)	NA		NA	NA	NA	NA	NA		NA
Other		0.05	2.64	482.34	NO	NO	0.72	-	16,766.39	17,252.16
Total area at the end of the current inventory year		35.46	358.12	16,041.89	3,904.33	608.15	82.89	NA	16,766.39	37,797.23

11.4.2.2. Overview of the procedures to estimate emissions and removals

This section gives an overview of the procedures to estimate emissions and removals for AR, D and FM activities in Japan. For AR and D activities, emissions and removals are estimated in AR and D areas which are detected for each prefecture based on sample survey data. For FM activity, emissions and removals are estimated by firstly subtracting emissions and removals in AR and D land from

those in all managed forests for each prefecture, and then applying the FM ratio determined by the sample survey to the remaining emissions and removals.

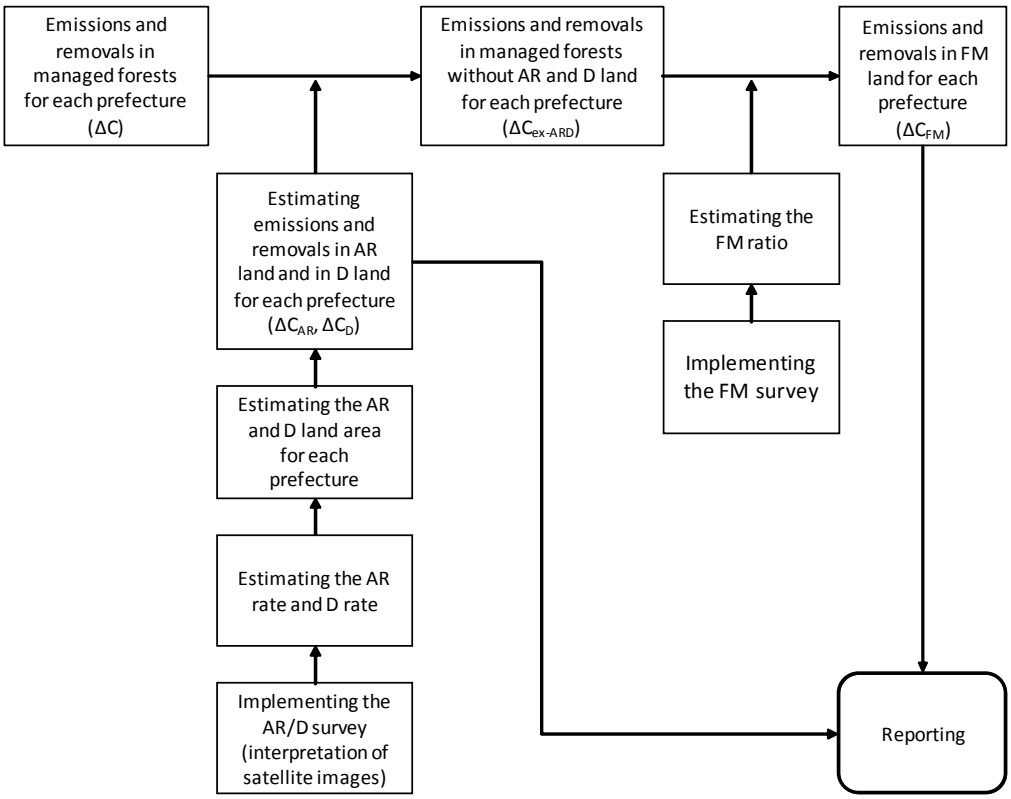

Figure 11-1 Procedures to estimate emissions and removals for AR, D and FM activities

11.4.2.3. Afforestation/Reforestation and Deforestation

11.4.2.3.a. Procedure

Japan identifies the change of forest cover in each sample plot by using orthophotos taken at the end of 1989 and recent satellite images, taking into account the spatial assessment unit (area 0.3 ha and width 20 m). Plots identified as non-forest land converted to forest land due to human-induced forestation practice are categorized as AR plot, and plots identified as forest land converted to non-forest land are categorized as D plot (Hayashi et al., 2008). Satellite images of alternating halves of all Japan are taken, updated and interpreted biennially. For example, images of the lower half of Japan were taken in 2012 and 2014, while images of upper half were taken and in 2011 and 2013. The interpretation through comparison of 2-year (2012 and 2014) satellites images are implemented in order to account for the carbon stock change in 2014. AR and D land areas are calculated based on the results of the interpretation. The detailed procedures are as follows:

1. The plot points on the whole country are set in a grid with an interval of 500 m (approximately 1,500 thousand plots).

2. Land conversion between forest and non-forest is detected at each plot point. Plots which are difficult to interpret are excluded from "available sample plots" which are used for the following estimation.

3. The AR rate for FY1990-FY2014 is estimated as follows: The increase in AR rate in each year during FY1990-FY2014 is estimated through dividing the increase of AR plots in each year,

which is obtained from the interpretation and comparison work using orthophotos taken at the end of 1989 and satellite images taken thereafter, by the number of "available sample plots" of each interpretation. The increase in AR plots in a year is detected covering half of the national land, and the increase in AR plots in the next year is detected covering the other half of the national land. The increase in AR rate in FY2014 is estimated by dividing the increase of AR plots in FY2014, which is the half of the two-year increase of AR plots obtained by comparing of satellite images of the year and two years before, by the number of "available sample plots". These satellite images are taken in areas that were not covered in the images taken in the year before.

4. The D rate for FY1990-FY2014 is estimated as follows: The increase in D rate in each year during FY1990-FY2014 is estimated through dividing the increase of D plots in each year, which is obtained from the interpretation and comparison work using orthophotos taken at the end of 1989 and satellite images taken thereafter, by the number of "available sample plots" of each interpretation. The increase in D plots in a year is detected covering half of the national land, and the increase in D plots in the next year is detected covering the half of the national land. The increase in D rate in FY2014 is estimated by dividing the increase of D plots in FY2014, which is the half of the two-year increase of D plots obtained by comparing of satellite images of the year and two years before, by the number of "available sample plots". These satellite images are taken in areas that were not covered in the images taken in the year before. The land-use status after D is analyzed from satellite images at each plot point and these data are used for the estimation of new land-use status in D land.

5. The AR land area for each prefecture during FY1990-FY2014 is calculated by multiplying the land area for each prefecture by the AR rate during FY1990-FY2014, which is obtained by summating the increase of AR rate in each year during FY1990-FY2014. In the same way, the D land area for each prefecture during FY1990-FY2014 is calculated by multiplying the land area for each prefecture by the D rate during FY1990-FY2014, which is obtained by summating the increase of D rate in each year during FY1990-FY2014.

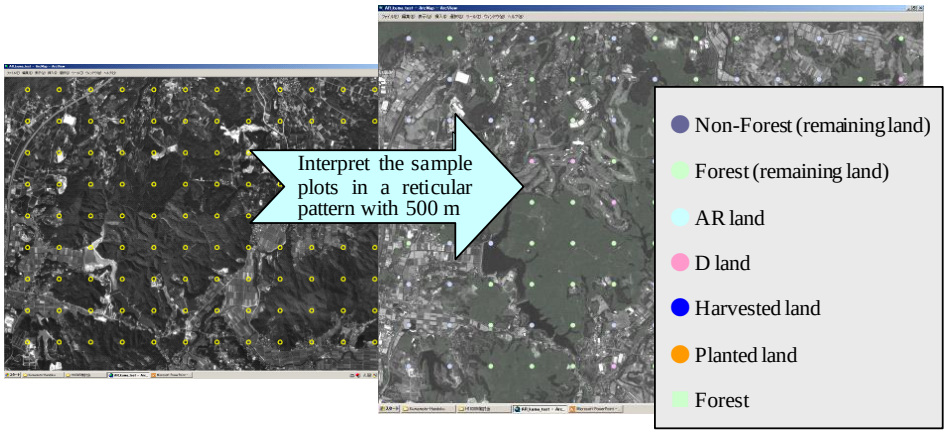

Figure 11-2 ARD land identification by interpreting remote sensing images

Although Forest Registers are used as basic data source for reporting since forests under the forest planning system are considered as forests under the Kyoto Protocol in Japan, orthophotos and satellite images are used for AR and D detection. This is because it is difficult to reconstruct the forest status during FY1990-FY2005 from the data in the Forest Registers, and to distinguish human-induced AR

from forest expansion due to other causes.

With respect to possible over- or under-estimation of D rate based on orthophotos and satellite images, there is a possibility that the D rate may be over-estimated. The reason is that there is a possibility that plots on cut-over forests, which have lost forest cover but not classified as deforested, and those on areas of decreasing tree cover in land other than forest land may be misidentified as D plots. Hence, Japan has implemented field surveys on a part of plots identified as D plots thus far. As a result of the surveys so far, about 70% of plots identified as D plots have been actually D plots, but about 30% of the plots have been plots on cut-over forests or on areas of decreasing tree cover in land other than forest land. In contrast, the result of double-checking a part of plots identified as not changed revealed that there were very few misidentifications; hence, possibility of under-estimation of D rate was extremely low. Therefore, it can be said that possibility of under-estimation of D rate is extremely low, but that the D rate may be over-estimated.

11.4.2.3.b. Data

Japan determines the ARD land area by using the following data.

Table 11-7 Data used in ARD land detection

	Resolution [m]	Data format
Ortho air-photo (at the end of 1989)	1	Raster
SPOT-5/HRV-P(at 2005, 2007, 2009 –2014)	2.5	Raster

11.4.2.3.c. Land-use change in deforested land

Japan determines the area of D land in accordance with the procedures mentioned in section 11.4.2.3.a. However, these procedures do not cover the continuous tracking of land-use change in D land. Therefore, the land-use change status in the D land has been assessed separately.

Japan has compiled land-use mesh data in the so called “Digital National Land Information” continuously over time. Although this mesh data cannot be used directly to monitor land-use change in the plots identified as D land because this mesh data is not absolutely consistent with the system mentioned in section 11.4.2.3.a (e.g. definition, resolution and land identification method), it can detect the overall tendency of land-use transition in the D plot. The results of the analysis of this mesh data show that D land is seldom converted to other land use again. Therefore, Japan assumes that the status of land use after D will continue to be the same and secondary land-use change will not occur.

11.4.2.4. Forest Management

11.4.2.4.a. Procedure

Japan estimates the FM land area for ikusei-rin forests and tennensei-rin forests according to the following procedures. As explained in section 11.3.2.1., forests to which activities for FM have been implemented since 1990 are subject to FM. Hence, if forests do not fulfill this condition, they are not counted as the forests subject to FM even if they are subject to managed forests reported under the Convention. Therefore, areas of the forests subject to FM are not equivalent to those of the managed forests under the Convention.

Areas subject to forest management are extracted from areas of remaining managed forests which are determined after the areas of deforestation have been subtracted from the area of the total managed forests of the previous year; hence, the area subject to forest management has reflects the decrease in forest management area resulting from deforestation. This means that the areas subject to forest

management are not overestimated.

a) Ikusei-rin forests

1. A field survey in private forests and national forests is implemented each year to identify lands which have been subject to FM activities (the number of sample plots are systematically distributed by tree species and regions; then, sample plots are selected randomly from the National Forest Resource Database (NFRDB)).

   Survey items: current status of forests (tree species, stand age, number of trees, etc.), status and contents of practices since 1990, etc.

2. The ratio of these FM land areas (FM ratio) is estimated according to the survey findings.

3. After the AR land area for each prefecture is subtracted from the total forest area, the remaining forest area for each prefecture is multiplied by the FM ratio for each tree species, regions and age class.

Table 11-8 FM ratio for ikusei-rin forests (private forests / national forests)

Sub-category / Tree species		Region	Private forest	National forest
Intensively managed forest	Japanese cedar	Tohoku, Kita-kanto, Hokuriku, Tosan	0.87	0.90
		Minami-kanto, Tokai	0.73	0.85
		Kinki, Chugoku, Shikoku, Kyusyu	0.74	0.88
	Hinoki cypress	Tohoku, Kanto, Chubu	0.84	0.90
		Kinki, Chugoku, Shikoku, Kyusyu	0.82	0.91
	Japanese larch	All	0.88	0.79
	Other	All	0.69	0.81
Semi-natural forest / All		All	0.36	0.65

* Data at the end of FY2014. About 21,600 sample plots are located all across the country.
* These regions generally used broad boundaries which aggregated several prefectures.
* FM ratios shown in this table are area-weighted average values of FM ratio for each age class.
* Uncertainty for FM ratios is 5% for entire Japan.

b) Tennensei-rin forests

For tennensei-rin forests, forest lands subject to practices for protection or conservation of forests such as controlling logging activities and land-use change which have been carried out by law are identified by using the NFRDB. Tennennsei-rin forests under Article3.4 of KP consist of Protection Forests, Special Zones and Special Protection Zones of National Parks and other protected forests/zones as shown in Table 11-9 below. The Protection Forests are designated under article 25 of the Forest Law (legislation No. 249 of 26th June, 1951) for the purpose of fulfilling forest multiple functions (such as headwater conservation and disaster prevention). In the Protection Forests, implementing cutting stands, changing land traits and related activities without prior permission is prohibited. In addition, placing signs which show the areas are Protection Forests, conducting field inspection and monitoring the areas by utilizing satellite images are implemented. With respect to the National Parks, the parks are protected by implementing restriction of development, prohibition of hunting animals and harvesting plants, restriction of changing land traits, limitation of people's and vehicles' accesses, based on the Natural Parks Law (legislation No.161 of 1st June, 1957). These measures have been applied to the Tennensei-rin forests under Article 3.4 of KP continuously after FY1990.

Table 11-9 Area of protected/conserved tennensei-rin forests

[Unit: kha]

Protected / Conserved forest type	Private forest	National forest	Total
Protection Forest	2,824	4,783	7,607
Area for Conservation facility installation project	1	0	1
Protected Forest	0	952	952
Special Protected Zones in National Parks	41	216	257
Class I Special Zones in National Parks	36	165	202
Class II Special Zones in National Parks	122	212	334
Special Protected Zones in Quasi-National Parks	9	56	65
Class I Special Zones in Quasi-National Parks	32	120	152
Class II Special Zones in Quasi-National Parks	99	85	184
Special Zone in National Environment Conservation Area	0	10	10
Special Seed Forest	1	1	1
Total	3,165 (2,730)	6,601 (4,605)	9,765 (7,335)

* NFRDB (1 April 2015)
* This table includes forests with less standing trees.
* ( ) means total land area excluding overlaps.

11.4.2.4.b. Data

a) Basic data for estimation

The basic data sources for FM estimation are Forest Registers and yield tables developed by prefectures or regional forest offices. Some of the yield tables are developed by the Forestry and Forest Products Research Institute. These Forest Registers and yield tables are also used for reporting under the Convention. Detailed information on Forest Registers and yield tables is provided in section 6.5.1.b) 1), Chapter 6 of this report.

b) Development of the National Forest Resources Database

To estimate emissions from or removals by forests, the Forestry Agency has developed the NFRDB. In the NFRDB, Forest Registers which are the basic data source for estimating and reporting, administrative information including forest planning maps and geographical location information such as orthophotos and satellite images like Landsat-TM and SPOT are archived.

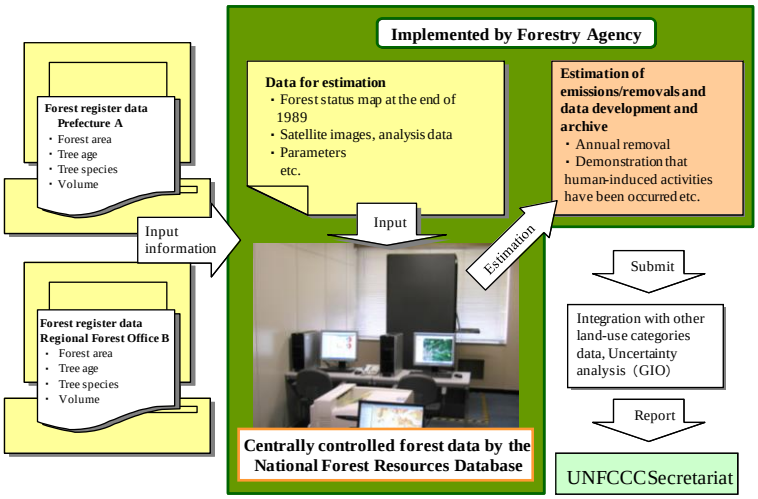

Figure 11-3 Summary of the National Forest Resources Database

11.4.2.5. Cropland Management

Basically, current cropland is subject to CM, area of CM was obtained from *Statistics of Cultivated and Planted Are*a by the MAFF in each prefecture for each land-use category (rice fields, upland fields and orchards). The information on data and definition of land use are the same as reporting of LULUCF under the Convention (see section 6.6 in Chapter 6 in this NIR).

Since, land which was converted from forest land to cropland is classified as D activity, area of CM were calculated by subtracting the area of cropland converted from forest land since 1990 obtained from the D survey, from the current area of rice fields, upland fields and orchards in each prefecture.

The land converted from cropland between 1991 and 2012 was not been included in the estimation because the land is not subject to CM activity in accordance with the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.*

In accordance with paragraph 24 of the annex to the decision 2/CMP.7, the land converted from cropland in the second commitment period since 2013 is included in area of CM activity; hence, the annul decrease area of cropland for each land-use category (rice fields, upland fields and orchard) in each prefecture obtained from *Statistics of Cultivated and Planted Are*a by the MAFF was included in area as "current non-cropland subject to CM activity". However, as plant area is classified as AR activity, the decrease of cropland area is calculated by subtracting annual area of afforrestation (AR) in cropland since 2013 obtained from the AR survey, from the area subject to CM activity.

11.4.2.6. Grazing Land Management

Method of determining and procedure for GM area are the same as the CM. Using the cultivation area of pasture in each prefecture obtained from *Statistics of Cultivated and Planted Area* by the MAFF as base data, area of GM was calculated by identifying area of current pasture, current non-pasture converted from pasture since 2013, past-pasture area subject to D activity and subject to AR activity by using the same method as CM.

11.4.2.7. Revegetation

11.4.2.7.a. Procedure

Japan estimates the RV land area by types of urban green facilities according to the following procedures.

a) Urban parks

1. The information on the notification date and the establishment areas are rearranged as of the end of each corresponding fiscal year during the commitment period for all urban parks which are installed in our country.

2. The urban parks which have been notified since 1 January 1990 and whose establishment area is 500 m^2 or more are extracted.

3. The urban parks extracted in step 2 are rearranged after address and the establishment areas determined by geographical boundary (prefecture) are counted.

4. The area of land which was classified as forest land on 31 December 1989 is calculated by multiplying the establishment area estimated in step 3 by the sum of the area ratios of "Land that has been converted from forest land to settlements per annum" since 1990 until each

corresponding fiscal year during the commitment period. This area is excluded from the establishment areas because it is classified as D. The remaining area is considered as RV land area.

5. The areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 4 by the area ratio of "Land converted to settlements" in the single year[5].

b) Green areas on roads

1. The number of tall trees at the end of each corresponding fiscal year during the commitment period is calculated for each geographical boundary (prefecture) based on the results of "Road Tree Planting Status Survey".

2. The number of tall trees on 31 March 1990 is calculated by using linear regression of two surveyed data sets (1986 and 1991) from the "Road Tree Planting Status Survey". Next, the number of tall trees for each prefecture on 31 March 1990 is calculated by multiplying these values by the ratio of the number of tall trees for each prefecture on 31 March 2007. The ratio of the number of tall trees on 31 March 1990 is fixed to the value on 31 March 2007.

3. The number of tall trees which have been planted since 1 April 1990 is calculated by subtracting the value estimated in step 1 from the value in step 2 (RV is considered to be an activity which takes place after 1 January 1990. However, Japan considers RV as an activity after 1 April 1990 because the "Road Tree Planting Status Survey" has been implemented on a fiscal year basis).

4. The ratio of the number of tall trees planted on roads with a planted area less than 500 m^2 is estimated by using data from the sampling survey implemented in 2006 (general road: 1.00%, expressway: 0.00%, significance level: 95%).

5. The land area per tall tree is estimated by using modeled data from the sampling survey implemented in 2006 (general road: 0.0062 ha/tree, expressway: 0.0008 ha/tree, significance level: 95%). (These modeled data are calculated by dividing randomly sampled RV land areas by the number of tall trees planted on the land).

6. The area of land planted with tall trees, which is 500 m^2 or more, is calculated by multiplying the values estimated in steps 4 and 5 by the number of tall trees for each geographical boundary (prefecture) estimated in step 3.

Area of land where tall trees have been planted since 1 April 1990 and whose size is 500 m^2 or more (ha) = Number of tall trees planted since 1 April 1990 (tree) * Ratio of the number of tall trees planted on land which is 500 m^2 or more (%) * Land area per tall tree (ha/tree)

7. The area of land which was classified as forest land on 31 December 1989 is calculated by multiplying the area estimated in step 6 by the sum of the area ratios of "Land that has been

[5] Land-use change from the previous year to each corresponding year is applied when the area ratio of "single year" is used.

converted from Forest land to settlements per annum" since 1990 until each corresponding fiscal year during the commitment period. This area is excluded because it is classified as D area. The remaining area is considered as RV land area.

8. The areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 7 by the area ratio of "Land converted to settlements" in the single year.

c) Green areas at ports

1. The green areas at ports which have been established since 1 January 1990 and which have a service area of 500 m^2 or more are extracted. Then, their areas are rearranged according to geographical boundaries (All green areas at ports can be reported because they are considered not to be classified as forest land on 31 December 1989).

2. The areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 1 by the area ratio of "Land converted to settlements" in the single year.

d) Green areas around sewage treatment facilities

1. The green areas around sewage treatment facilities which have been established since 1 January 1990 and which have a greening area of 500 m^2 or more are extracted. Then, their areas are rearranged according to geographical boundaries.

2. The area of land which was classified as forest land on 31 December 1989 is calculated by multiplying the greening areas estimated in step 1 by the sum of the area ratios of "Land that has been converted from Forest land to settlements per annum" since 1990 until each corresponding fiscal year during the commitment period. This area is excluded because it is classified as D area. The remaining area is considered as RV land area.

3. The areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 2 by the area ratio of "Land converted to settlements" in the single year.

e) Green areas by greenery promoting systems for private green space

1. The green areas by greenery promoting systems for private green space which have a greening area (excluding wall green areas) of 500 m^2 or more are extracted and their areas are rearranged according to geographical boundaries. All of them are activities which took place after 1 January 1990 because greenery promoting systems have been implemented since May 2001.

2. All green areas by greenery promoting systems for private green space to be reported are "Remaining land (settlements remaining settlements)" because they were not classified as Forest land on 31 December 1989, and land-use conversion, if any in recent years, occurred only within settlements.

f) Green areas along rivers and erosion control sites

1. The greening works and erosion and sediment control works including hillside works in river zones which have been established since 1 January 1990 and which have a greening area of 500 m^2 or more are extracted (greening works: (1) – (8), erosion and sediment control works: (9) – (11) in the following table).

Table 11-10 RV projects in green areas along rivers and erosion control sites and definition of planted land area

RV works in green areas along rivers and erosion control sites	Definition of planted land area
(1) Planting in inspection passage of excavated channel	Area of land from levee wall shoulder to private land
(2) Planting in face of river bank of excavated channel	Area of land from levee wall shoulder to private land
(3) Planting in backslope banquette	Area of embanked land
(4) Planting in levee marginal strip (second-class and third-class)	Area of marginal strip which is subject to greening works
(5) Planting in high water channel	Area of land from low-flow channel shoulder to foot of levee slope
(6) Planting in retarding basin	Area of retarding basin
(7) Planting in lake foreshore	Area of land from low-flow channel shoulder to foot of levee slope
(8) Planting in super levee	(Same as planting in excavated channel)
(9) Greening under erosion and sediment control works	Area of land which is subject to hillside works
(10) Greening under landslide control works	Area of land which is subject to hillside works
(11) Greening under steep slope failure prevention works	Area of land which is subject to hillside works

2. The planted land area in green areas along rivers and erosion control sites for each geographical boundary (prefecture) extracted in step 1 is calculated. Double-counting between RV land and D land is prevented because forested land (on 1 January 1990) is not included in step 1.

3. The land areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 2 by the area ratio of "Land converted to settlements (excluding forest land converted to settlements)" in the single year.

g) Green areas around government buildings

1. The green areas around government buildings which have been established since 1 January 1990 and whose RV land area (= total land area - building area) is 500 m^2 or more are extracted.

2. The RV land area for each geographical boundary (prefecture) extracted in step 1 is calculated.

3. The area of land which was classified as Forest land on 31 December 1989 is calculated by multiplying the land area estimated in step 2 by the sum of the area ratios of "Land that has been converted from Forest land to settlements per annum" since 1990 until each corresponding fiscal year during the commitment period. This area is excluded because it is classified as D area. The remaining area is considered as RV land area.

4. The areas of "remaining land (settlements remaining settlements)" and "land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 3 by the area ratio of "land converted to settlements" in the single year.

h) Green areas around public rental housing

1. The green areas around public rental housing which have been established since 1 January 1990 and which have a RV land area (= total land area - building area) of 500 m^2 or more are extracted.
2. The RV land area for each geographical boundary (prefecture) extracted in step 1 are calculated.
3. The area of land which was classified as Forest land on 31 December 1989 is calculated by multiplying the land area estimated in step 2 by the sum of the area ratios of "Land that has been converted from Forest land to settlements per annum" since 1990 until each corresponding fiscal year during the commitment period. This area is excluded because it is classified as D area. The remaining area is considered as RV land area.
4. The areas of "Remaining land (settlements remaining settlements)" and "Land converted from other land-use categories (cropland / grassland / wetlands / other land converted to settlements)" are calculated by multiplying the land area estimated in step 3 by the area ratio of "Land converted to settlements" in the single year.

11.4.2.7.b. Data

The data applied in estimating RV land area are shown below.

Table 11-11 Data applied in estimating RV land area

Sub-division	Data type	Method for data collection
Urban parks	Area for each urban park	Urban Parks Status Survey (FY2008, 2009, 2010, 2011, 2012, 2013, 2014)
Green area on roads	Number of tall trees	Road Tree Planting Status Survey (FY1987, 1992, 1997, 2002, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015)
	Land area per tall tree	Basic Data Collection Survey on Tall Tree Planting on Roads (February, 2007)
Green areas at ports	Service area	Complete census for FY2008, 2009, 2010, 2011, 2012,2013, 2014
Green areas around sewage treatment facilities	Green area	Sewage Treatment Facility Status Survey (FY2008, 2009, 2010, 2011, 2012, 2013, 2014)
Green areas by greenery promoting systems for private green space	Greening area Wall greening area Number of tall trees	Application form for greenery promoting systems for private green space Urban Greening Status Survey (FY2008, 2009, 2010, 2011, 2012,2013, 2014)
Green areas along river and erosion control sites	Planted land area	Survey on carbon dioxide absorption at source in river works (FY2008, 2009, 2010, 2011, 2012, 2013, 2014)
Green areas around government buildings	Total land area and building area	Complete census for FY2008, 2009, 2010, 2011, 2012, 2013, 2014
Green areas around public rental housing	Total land area and building area	Progress survey on tree planting for public rental housing (FY2008, 2009, 2010, 2011, 2012, 2013, 2014)

11.4.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Section 2.2.2 of the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* shows two methods for identifying and reporting the units of land subject to Article 3.3 activities and lands subject to Article 3.4 activities. Reporting Method 1 entails delineating areas that include multiple land units subject to Article 3.3 and 3.4 activities by using legal, administrative, or ecosystem boundaries. Reporting Method 2 is based on the spatially explicit and complete geographical identification of all units of land subject to Article 3.3 activities and all lands

subject to Article 3.4 activities.

Japan elects Reporting Method 1 in accordance with the decision tree indicated in Figure 2.2.2 in Chapter 4 of the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*, which means that the entire national land is stratified by using the geographic boundary of prefectures, and the total area of each "unit of land" subject to each Article 3.3 activity and each "land" subject to each Article 3.4 activity is reported within each boundary. The identification code is determined for each prefecture as shown in the following map (see Table 11-12). Each activity under Articles 3.3 and 3.4 is detected as described in sections 11.4.2.3-11.4.2.7 and the units of land or lands subject to it are identified within prefectural boundaries in accordance with Reporting Method 1.

This geographical boundary is applied for all units of land: units of land subject to activities under Article 3.3, units of land subject to activities under 3.3 which would otherwise be included in land subject to forest management or elected activities under Article 3.4, under the provisions of paragraph 9 of the annex to the decision 2/CMP.7, and lands subject to forest management and to nay elected activities under Article 3.4.

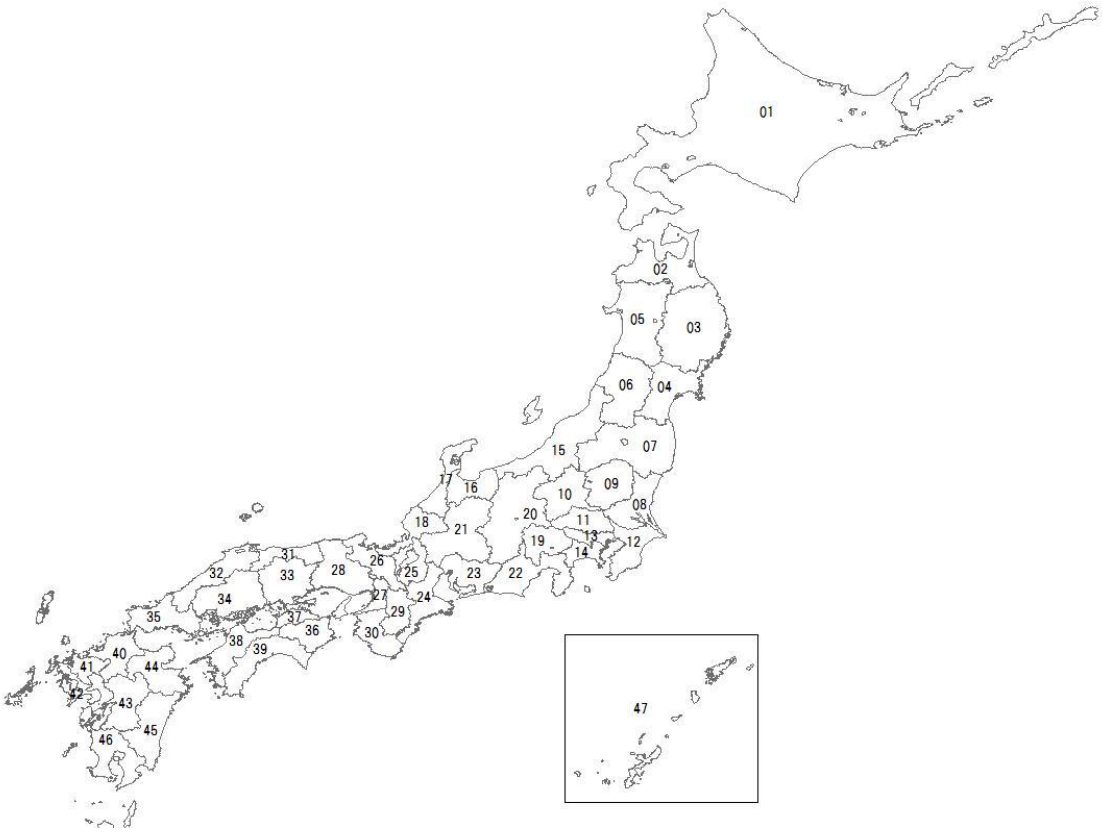

Figure 11-4 Japan's determination of identification codes

Table 11-12 Identification codes and prefectures

ID	Prefecture	ID	Prefecture	ID	Prefecture	ID	Prefecture	ID	Prefecture
01	Hokkaido	11	Saitama	21	Gifu	31	Tottori	41	Saga
02	Aomori	12	Chiba	22	Shizuoka	32	Shimane	42	Nagasaki
03	Iwate	13	Tokyo	23	Aichi	33	Okayama	43	Kumamoto
04	Miyagi	14	Kanagawa	24	Mie	34	Hiroshima	44	Oita
05	Akita	15	Niigata	25	Shiga	35	Yamaguchi	45	Miyazaki
06	Yamagata	16	Toyama	26	Kyoto	36	Tokushima	46	Kagoshima
07	Fukushima	17	Ishikawa	27	Osaka	37	Kagawa	47	Okinawa
08	Ibaraki	18	Fukui	28	Hyogo	38	Ehime		
09	Tochigi	19	Yamanashi	29	Nara	39	Kochi		
10	Gunma	20	Nagano	30	Wakayama	40	Fukuoka		

11.5. Activity-specific information

11.5.1. Methods for carbon stock change and GHG emission and removal estimates

11.5.1.1. Description of the methodologies and the underlying assumptions used

11.5.1.1.a. Afforestation/Reforestation

a) Above-ground biomass, Below-ground biomass

- ***Methodology***

The carbon stock change in living biomass in AR land is calculated using the Tier 2 stock difference method in accordance with the *2006 IPCC Guidelines*. In this method, the biomass stock change is estimated by subtracting the biomass stock change due to land conversion from the difference between the total amount of biomass at two times.

$$\Delta C_{LB} = \Delta C_{SC} - \Delta C_{L}$$

ΔC_{LB} : Annual carbon stock change in living biomass [t-C/yr]

ΔC_{SC} : Annual carbon stock change due to biomass growth, felling, fuelwood gathering, disturbance after land conversion [t-C/yr]

ΔC_{L} : Annual carbon stock change due to land conversion [t-C/yr]

Carbon stock change due to biomass growth, felling, fuelwood gathering and disturbance after land conversion

$$\Delta C_{SC} = \sum_{k} \left\{ (C_{t2} - C_{t1}) / (t_2 - t_1) \right\}_k$$

ΔC_{SC} : Annual carbon stock change in living biomass [t-C/yr]

t_1, t_2 : Time point of carbon stock measurement

C_{t1} : Total carbon in biomass calculated at time t_1 [t-C]

C_{t2} : Total carbon in biomass calculated at time t_2 [t-C]

k : Type of forest management

The carbon stocks in living biomass are calculated from the volume for each tree species multiplied by

wood density, biomass expansion factor, root-to-shoot ratio and carbon fraction.

$$C = \sum_j \left\{ [V_j \times D_j \times BEF_j] \times (1 + R_j) \times CF \right\}$$

C	: Carbon stock in living biomass [t-C]
V	: Volume [m^3]
D	: Wood density [t-d.m./m^3]
BEF	: Biomass expansion factor [dimensionless]
R	: Root-to-shoot ratio [dimensionless]
CF	: Carbon fraction (Conifer: 0.51[t-C/t-d.m.], Broad leaf: 0.48[t-C/t-d.m.])
j	: Tree species

Carbon stock change due to land conversion

The carbon stock change due to land conversion is calculated as below, in accordance with the *2006 IPCC Guidelines*.

$$\Delta C_L = \sum_i \left\{ A_i \times (B_a - B_{b,i}) \times CF \right\}$$

ΔC_L	: Annual biomass carbon stock change in land that has been converted from other land-use type to forest [t-C/yr]
A_i	: Annual increase of land area that has been converted from land-use type i to forest [ha/yr]
Ba	: Dry matter weight per unit area immediately after conversion to forest [t-d.m./ha]
Bb,i	: Dry matter weight per unit area before conversion from land-use type i to forest [t-d.m./ha]
CF	: Carbon fraction of dry matter [t-C/t-d.m.]
i	: Type of land use

- ***Parameters***

Data such as volume, biomass expansion factor, root-to-shoot ratio, wood density and carbon fraction are the same as those for reporting of LULUCF under the Convention. Detailed information is provided in section 6.5.1, Chapter 6 of this report.

The biomass stock data for each land use category which is used for estimation of biomass stock change due to land conversion are also the same as those for reporting of LULUCF under the Convention. Detailed information is provided in Table 6-8a, Chapter 6 of this report.

- ***Activity data***

The activity data is AR land area which was calculated by using the procedure described in section 11.4.2.3 of this report.

b) Dead wood, Litter and Soils

- ***Methodology***

The carbon stock change in dead wood and litter in AR land is calculated in accordance with the basic stock difference method provided by the *2006 IPCC Guidelines* under the assumption that carbon stocks would change linearly over 20 years from those in non-forest land to those in forest land at the age of 20. The calculation is conducted by using average carbon stocks derived from the

CENTURY-jfos model, and carbon stocks in dead wood and litter before land conversion are assumed to be zero.

$$\Delta C_{DW} = \sum_i \left\{ A_i \times (C_{DW\,20} - C_{DW,i}) / 20 \right\}$$

$$\Delta C_{LT} = \sum_i \left\{ A_i \times (C_{LT\,20} - C_{LT,i}) / 20 \right\}$$

ΔC_{DW} : Annual carbon stock change in dead wood [t-C/yr]
ΔC_{LT} : Annual carbon stock change in litter [t-C/yr]
A_i : Afforested or reforested land area converted from land use i [ha]
C_{DW20} : Average carbon stocks in dead wood per unit area of 20-year-old forests [t-C/ha]
C_{LT20} : Average carbon stocks in litter per unit area of 20-year-old forests [t-C/ha]
$C_{DW,i}$: Average carbon stocks in dead wood per unit area of land-use i [t-C/ha] (assumed to be zero)
$C_{LT,i}$: Average carbon stocks in litter per unit area of land-use i [t-C/ha] (assumed to be zero)
i : Type of land-use (cropland, grassland, wetlands, settlements and other land)

The carbon stock change in soils in AR land is calculated in accordance with the basic stock change method provided by the *2006 IPCC Guidelines* under the assumption that carbon stocks would change linearly over 20 years from those in non-forest land to those in forest land at the age of 20. This calculation is conducted by using average carbon stocks derived from the CENTURY-jfos model.

As mentioned in "Forest land remaining forest land" (section 6.5.1.b).2)), soil drainage activities for organic soil in forest land are not implemented in general in Japan, and it is considered as same for forests subject to AR activity. Therefore, the emissions from organic soils are reported as "NO".

$$\Delta C_{Soil} = \sum_i \left\{ A_i \times (C_{Soil\,20} - C_{Soil,i}) / 20 \right\}$$

ΔC_{Soil} : Annual carbon stock change in soils [t-C/yr]
A_i : Afforested or reforested land area converted from land-use i [ha]
C_{Soil20} : Average carbon stocks in soils per unit area of 20-year-old forests [t-C/ha]
$C_{Soil,i}$: Average carbon stocks in soils per unit area in land-use i [t-C/ha]
i : Type of land use (cropland, grassland, wetlands, settlements and other land)

- ***Parameters***

The parameters are determined based on the CENTURY-jfos model and relevant literature.

- ***Activity data***

The AR land area is calculated by using the procedure described in section 11.4.2.3 of this report.

c) Harvested Wood Products (HWP)

HWP from forest land subject to AR activity was reported as "NO" because supply of wood used as HWP from AR land do not occur in Japan.

d) Other gases

1) Direct and inderect N_2O emissions from N fertilization

The amount of nitrogen-based fertilizer applied in Forest land cannot be separated to those in AR and

in FM. Hence, N_2O emissions from N fertilization are reported in FM in a lump. Therefore, this category in AR has been reported as "IE".

2) N_2O and CH_4 emissions from drainage of soils

Soil drainage in forest land with organic soils is not implemented in Japan. N_2O and CH_4 emissions from organic soils in forest land do not occur and were reported as "NO".

3) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

In accordance with less than Tier 2 methodology described in *the 2006 IPCC Guidelines*, N_2O emissions from N immobilization associated with gain of soil organic matter were not estimated. N_2O emissions from AR land were reported as "NA" because soil carbon in AR land has been generally increasing and N_2O emssions do not occur.

4) Biomass burning

GHG emissions from wild fire exist in Japan as explained in section 6.16.b) 1), Chapter 6 of this report. Since there is no data which directly express biomass burning status in AR land, GHG emissions in AR land are estimated by multiplying GHG emissions due to fire for all forest land by the ratio of AR land area to all forest land area. Carbon released due to fire for all forest land (national forests and private forests) is estimated by multiplying the damaged timber volume due to fire by wood density, biomass expansion factor and carbon fraction of dry matter. Calculations only for non CO_2 emissions are performed since CO_2 emissions are already included in the calculation of carbon stock change.

e) Results

Table 11-13 Net emissions and removals from AR activity

		2013	2014
		[kt-CO_2 eq.]	[kt-CO_2 eq.]
AR		-532.44	-531.45
	Above-ground biomass	-305.01	-303.06
	Below-ground biomass	-78.78	-78.25
	Dead wood	-104.90	-108.00
	Litter	-33.12	-31.78
	Soils	-10.64	-10.40
	Harvested wood products (HWP)	NO	NO
	Other gases	0.01	0.04

* CO_2) +: Emission, -: Removal

11.5.1.1.b. Deforestation

a) Above-ground biomass, Below-ground biomass

- ***Methodology***

The carbon stock change of living biomass (above-ground biomass and below-ground biomass) in D land is estimated by adding the living biomass loss in forests due to land conversion and carbon stock change due to growth of living biomass in D land after land conversion, in accordance with the *2006 IPCC Guidelines*.

The forest living biomass loss due to land conversion is estimated from data in the NFRDB taking into account the status of D land such as tree species and forest, and all loss is allocated as emissions for the year of land conversion.

The carbon stock change due to growth of living biomass is estimated according to land use after conversion in D land. The land-use categories, except forest land where living biomass growth after conversion is calculated, are "land converted to grassland" and "land converted to settlements" as explained in Table 6-8b in Chapter 6 of this report. D land which is converted to settlement with living biomass growth is the land subject to RV practices. This is the land subject to both Article 3.3 and 3.4 activities, and the carbon stock change in this land is reported under D activity. The calculation is performed according to land-use status immediately after conversion in D land taking into account that D land is assumed to be seldom converted to other land uses again as explained in section 11.4.2.3.c.

$$\Delta C_{D-LB} = \Delta C_{DG-LB} + \Delta C_{DS-LB}$$
$$\Delta C_{DG-LB} = A_{5,DG} \times C_{G-LB}$$
$$\Delta C_{DS-LB} = \Delta C_{RV-LB} \times RA_{DS-RV}$$

$\Delta C_{D\text{-}LB}$: Annual carbon stock change due to living biomass growth after D activity [t-C/yr]
$\Delta C_{DG\text{-}LB}$: Carbon stock change due to living biomass growth in grassland subject to D activity [t-C/yr]
$\Delta C_{DS\text{-}LB}$: Carbon stock change due to living biomass growth in settlements subject to D activity [t-C/yr]
$\Delta C_{RV\text{-}LB}$: Carbon stock change in living biomass due to all RV practices [t-C/yr] (see section 11.5.1.1.f)
$A_{5,DG}$: Area of grassland subject to D activity within the past 5 years [ha]
$C_{G\text{-}LB}$: Carbon stock change per area in grassland [t-C/ha/yr]
$RA_{DS\text{-}RV}$: Ratio of the area subject to both D and RV activities within all areas subject to RV activities

- ***Parameters***

Information relating to loss of forest biomass is obtained from the NFRDB. The parameter in Table 6-8b in Chapter 6 of this report is used for estimating carbon stock change due to living biomass growth after D activity in grassland. The parameters for estimating carbon stock change due to RV practices are the same as those used for RV activity.

- ***Activity data***

The D land area is calculated by the method described in section 11.4.2.3. The D land area where RV practices have been taken place is calculated by the method described in section 11.5.1.1.f.

b) Dead wood, Litter and Soils

The carbon stock change in dead wood, litter and soils associated with D is calculated in accordance with the Tier 2 method in the *2006 IPCC Guidelines*. Japan assumes that all carbon stocks in dead wood and litter are emitted at the time when D activities occur. The carbon stock change in mineral soils is calculated under the assumption that soil carbon stocks change linearly over 20 years from those in forest land to those in non-forest land. Carbon stocks before and after conversion are established based on the data in Tables 6-8 to 6-11 in Chapter 6 of this report, and data obtained from the CENTURY-jfos model.

Land-use changes from forest land with organic soils hardly occur in Japan; therefore, the emissions

from organic soils are reported as "NO".

c) Harvested Wood Products (HWP)

Carbon stock change of HWP in D land was reported as "IO" because HWP from D land was accounted for on the basis of instantaneous oxidation in accordance with the decision 2/CMP.7.

d) Other gases

1) Direct and indirect N_2O emissions from N fertilization

The fertilization in deforestation process has not been implemented in Japan. N_2O emissions from N fertilization in land after conversion are included in the estimation of the agriculture sector. Therefore, the emissions in this category were reported as "IE".

2) N_2O and CH_4 emissions from drainage of soils

Soil drainage in forest land with organic soils is not implemented in Japan. N_2O and CH_4 emissions from organic soils from this category do not occur and were reported as "NO".

3) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

N_2O emissions from nitrogen mineralization associated with loss of soil organic matter were calculated by using Tier 1 estimation method described in the *2006 IPCC Guidelines*. The estimation equation and parameters used are the same as section 6.14 in Chapter 6 in this NIR. All carbon loss due to deforestation is used as annual amount of loss of soil carbon of N mineralized in mineral soils.

4) Biomass burning

Prescribed fire associated with D activity does not occur in Japan because of severe restrictions imposed by the "Waste Management and Public Cleansing Law" and the "Fire Defense Law". Therefore, CH_4, CO, N_2O, and NO_x emissions from biomass burning in D land are reported as "NO".

e) Results

Table 11-14 Net emissions and removals from D activity

		2013	2014
		[kt-CO_2 eq.]	[kt-CO_2 eq.]
D		1,493.12	2,134.04
	Above-ground biomass	700.66	1,044.47
	Below-ground biomass	176.80	264.96
	Dead wood	319.76	472.65
	Litter	129.14	191.46
	Soils	146.48	140.98
	Harvested wood products (HWP)	IO	IO
	Other gases	20.28	19.52

* CO_2) +: Emission, -: Removal

11.5.1.1.c. Forest Management

a) Above-ground biomass, Below-ground biomass

- ***Methodology***

1. Emissions/removals in all forest land are estimated by using biomass stock data stored in the NFRDB (based on the stock difference method).

2. Emissions/removals relating to ARD activities are subtracted from emissions/removals in all forest land. For ikusei-rin forest, emissions/removals in FM land are estimated by applying the FM ratio for each tree species, region and age class[6,7]. For tennensei-rin forest, the areas of forest land with standing trees subject to practices for protection or conservation of forests such as controlling logging activities and land-use change which have been implemented under laws are identified by using the NFRDB, and emissions/removals are estimated.

- ***Parameters***

The parameters are the same as those used for AR.

b) Dead wood, Litter and Soils

- ***Methodology***

The carbon stock changes in dead wood, litter and mineral soil pools are estimated by the Tier 3 method. It is estimated by multiplying carbon emissions/removals per area in each pool, which are calculated by the CENTURY-jfos model for each type of forest management, by the land area of each type of forest management and then summating them.

$$\Delta C_{dls} = \sum_{k,m,j} \left\{ A_{k,m,j} \times (d_{k,m,j} + l_{k,m,j} + s_{k,m,j}) \right\}$$

ΔC_{dls} : Carbon stock change in dead wood, litter and soil [t-C/yr]
A : Area [ha]
d : Average carbon stock change in dead wood per unit area [t-C/ha/yr]
l : Average carbon stock change in litter per unit area [t-C/ha/yr]
s : Average carbon stock change in mineral soils per unit area [t-C/ha/yr]
k : Type of forest management
m : Age class or forest age
j : Tree species

CO_2 emissions from organic soil do not occur because soil drainage activities for organic soil in forest land were not implemented in Japan. Therefore, this category is reported as "NO".

- ***Parameters***

The average carbon stock changes per unit area for dead wood, litter and soils are calculated by the CENTURY-jfos model, which was the modified version of the CENTURY model (Colorado State

[6] Only a part of stock losses may be accounted for as FM removals/emissions, when carbon stock changes obtained through the stock change method are multiplied by the FM ratios. In order to avoid this, all stock losses resulted from harvesting are included in the estimation of FM removals/emissions.

[7] When prefectures and Regional Forest Offices update the Forest Registers, the Registers' data like tree species or areas may be revised in order to reflect the current status of forests. In this case, FM removals/emissions are modified to obtain values based on appropriate carbon stock changes. Without modification, the difference between carbon stock without revision at a time point and carbon stock with revision at another time point would be regarded as the carbon stock change between the two points of time under the stock change method, and it would not reflect the correct removals or emissions.

University) to accommodate for Japanese climate, soil, and vegetation conditions. Detailed explanation of the CENTURY-jfos model is provided in section 6.5.1.b) 2), Chapter 6 of this report.

c) Harvested Wood Products (HWP)

HWP under FM is the same of the HWP reporting of LULUCF under the Convention; carbon stock change in sawnwood, wooden board, and plywood used in buildings were estimated by using Tier 3 country-specific method. As for wood used for other than buildings (sawnwood, wooden board, plywood) and paper and paperboard, Tier 2 method described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* were used for calculation. The estimation equation, parameters used and activity data are the same as section 6.11 in Chapter 6 in this NIR.

d) Other gases

1) Direct and indirect N_2O emissions from N fertilization

N_2O emissions from N fertilization exist in Japan as explained in section 6.12, Chapter 6, of this report, even though their quantity is a very little. The amount of nitrogen-based fertilizer applied in Forest land cannot be separated to those in AR and in FM. Hence, N_2O emissions from N fertilization are reported in FM in a lump. With respect to the methodology and parameters applied to this category, see section 6.12, Chapter 6, of this report.

2) N_2O and CH_4 emissions from drainage of soils

Soil drainage activity for organic soils in forest land does not occur in Japan, this category is reported as “NO”.

3) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

N_2O emissions from N mineralization associated with loss of soil organic matter is estimated by using Tier 1 method described in the *2006 IPCC Guidelines*. The estimation method and parameters are the same as section 6.14 and section 6.15 in Chapter 6 in this NIR. The activity data was gross loss of soil carbon which was extracted from land that soil carbon has reduced by each tree age and tree species in each prefecture.

4) Biomass burning

Emissions due to biomass burning are estimated in the same way as in the case of AR by multiplying GHG emissions due to fire for all forest land by the ratio of FM land area to all forest land area.

e) Results

Table 11-15 Net emissions and removals from FM activity

		2013	2014
		[kt-CO_2 eq.]	[kt-CO_2 eq.]
FM		-51,070.04	-50,033.24
	Above-ground biomass	-41,410.15	-39,898.16
	Below-ground biomass	-10,475.59	-10,081.55
	Dead wood	2,058.27	2,114.09
	Litter	-229.26	-224.70
	Soils	-1,486.62	-1,438.04
	Harvested wood products (HWP)	374.70	-621.18
	Other gases	98.62	116.29

* CO_2) +: Emission, -: Removal

11.5.1.1.d. Cropland Management

a) Above-ground biomass, Below-ground biomass

- ***Methodology***

Carbon stock changes in living biomass in orchard were estimated by using Tier 2 stock-difference method described in the *2006 IPCC Guidelines*.

As for estimation equation, parameters used and activity data, see section 6.6.1.b) 1) in Chapter 6 in this NIR.

b) Dead Wood, Litter

Dead wood and litter in rice fields and in upland fields do not occur. In orchards, the practices that accumulate dead organic matter on the soil are not implemented. Therefore, carbon stocks are not changed over time and are not net sources. Hence, the carbon stock changes are treated as "NA" and reported as "NR" in the CRF-NIR table 1.

c) Soils

- ***Methodology***

1) Mineral soil

Carbon stock changes in mineral soils in CM were estimated by applying the tier 3 model (Roth C) estimation method. For detailed information on the method, see section 6.6.1.b) 2) in Chapter 6 in this NIR.

2) Organic soil

On-site CO_2 emissions from organic soils in rice fileds and in upland fileds were estimated by applying Tier 1, 2 described in the *2006 IPCC Guidelines*. Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils in rice fields and upland fields were estimated by applying Tier 1 described in section 2.2.2.1 in the *Wetlands Guidelines*. For detailed information on the method, see section 6.6.1.b) 2) in Chapter 6 in this NIR.

- ***Parameters***

Parameters used are the same as section 6.6.1.b) 2) in Chapter 6 in this NIR.

- ***Activity data***

As for land subject to CM activity in current cropland obtained by method described in section 11.4.2.5, areas of mineral soil and organic soil were estimated by using the ratio of organic soil for rice fields, upland fields, and orchards in each prefecture, and were used for estimating as activity data, respectively.

As for land subject to CM activity in current non-cropland, as explanation described in Box1.1 in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*, emissions and removals are treated as zero. Hence, the area subject to CM activity in current non-cropland is not included in activity data to be used for estimating. For calculation of ratio of organic soil, see section 6.6.1.b) 2) in Chapter 6 in this NIR.

d) Other gases

1) CH_4 emissions from drainage of soils

CH_4 emissions from drainage of organic soils in upland fields were estimated by applying Tier 1 method described in section 2.2.2.1 in the *Wetlands Guidelines*. The estimation equation and parameters used are the same as section 6.13 in Chapter 6 in this NIR. The activity data is the same as section 6.6.1.b) 2) in Chapter 6 in this NIR.

2) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

Since the emissions from cropland converted from other-land use is subject to CM, the emissions calculated for reporting of LULUCF under the Convention are reported. The estimation equation and parameters used and activity data are the same as section 6.14 in Chapter 6 in this NIR.

3) Biomass burning

Non-CO_2 emissions from burning of pruned branches from orchard trees were reported as part of the GHG emissions in CM land. The estimation method, parameters used and activity data are the same as section 6.16.b) 2) in Chapter 6 in this NIR.

e) Results

Table 11-16 Net emissions from CM activity

		1990	2013	2014
		[kt-CO_2 eq.]	[kt-CO_2 eq.]	[kt-CO_2 eq.]
CM		10,261.57	3,553.69	4,328.38
	Above-ground biomass	163.25	89.18	85.55
	Below-ground biomass	120.46	54.17	51.90
	Dead wood	NA	NA	NA
	Litter	NA	NA	NA
	Soils (mineral)	8,180.69	1,789.60	2,573.68
	Soils (organic)	1,669.59	1,553.81	1,550.67
	Non-CO_2 (organic soil)	36.56	34.85	34.77
	Non-CO_2 (N mineralization)	59.35	10.19	10.25
	Non-CO_2 (biomass burning)	31.67	21.88	21.58

* CO_2) +: Emission, -: Removal

11.5.1.1.e. Grazing Land Management

a) Above-ground biomass, Below-ground biomass

- ***Methodology***

Carbon stock gain in living biomass in grassland converted from land other than forest land was reported. The estimation equation, parameters used and activity data are the same as sections 6.7.2.b) 1) in Chapter 6 and 11.4.2.6 in Chapter 11 in this NIR.

b) Dead Wood, Litter

Carbon stocks in dead wood and litter in grassland in Japan are negligible, and carbon stock changes are assumed to be zero. Therefore, the carbon stock changes are treated as "NA" and are reported as "NR" in the CRF-NIR table 1 because these carbon pools are not net sources of GHGs.

c) Soils

- ***Methodology***

1) Mineral soil

Carbon stock changes in mineral soils in GM were estimated by applying the tier 3 model (Roth C) estimation method. For detailed information on the method, see section 6.6.1 b 2) in Chapter 6 in this NIR.

2) Organic soil

On-site CO_2 emissions from organic soils in pasture land were estimated by applying the Tier 1 estimation method described in section 6.2.3.1 in the *2006 IPCC Guidelines*. The estimation method is the same as cropland remaining cropland. Off-site CO_2 emissions via waterborne carbon losses from drained inland organic soils were estimated by applying Tier 1 estimation method described in the *Wetlands Guidelines*. For detailed information on the method, see section 6.6.1.b) 2) in Chapter 6 in this NIR.

- ***Parameters***

Parameters used are the same as section 6.6.1.b) 2) in Chapter 6 in this NIR.

- ***Activity data***

Regarding area subject to GM activity in current pasture land obtained by using method described in section 11.4.2.6, areas of mineral soil and organic soil were estimated by using the ratio of organic soil by prefecture, and were used for estimating as activity data, respectively. As explanation described in Box1.1 in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*, since emissions and removals are treated as zero, the area subject to GM activity in current non-pasture land is not included in activity data to be used for the estimation. For calculation of ratio of organic soil in pasture land, see section 6.7.1.b) 1) in Chapter 6 in this NIR.

d) Other gases

1) CH_4 emissions from drainage of soils

CH_4 emissions from drainage of organic soils in pasture land were estimated by applying Tier 1 method described in section 2.2.2.1 in the *Wetlands Guidelines*. The estimation equation and parameters used are the same as section 6.13 in Chapter 6 in this NIR. The activity data is the same as

section 6.7.1.b) 1) in Chapter 6 in this NIR.

2) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

Estimation equation, parameters used and activity data are the same as section 6.14 in Chapter 6 in this NIR.

3) Biomass burning

Emissions from biomass burning in GM were reported as "NO" because open burning in pasture land do not occur in Japan.

e) Results

Table 11-17 Emissions and removals from GM activity

		1990	2013	2014
		[kt-CO_2 eq.]	[kt-CO_2 eq.]	[kt-CO_2 eq.]
GM		840.66	-299.54	-90.22
	Above-ground biomass	-11.73	-2.96	-2.31
	Below-ground biomass	-46.91	-11.85	-9.26
	Dead wood	NA	NA	NA
	Litter	NA	NA	NA
	Soils (mineral)	863.82	-320.39	-114.15
	Soils (organic)	27.99	28.47	28.34
	Non-CO_2 (organic soil)	2.19	2.23	2.22
	Non-CO_2 (N mineralization)	5.29	4.97	4.94

* CO_2) +: Emission, -: Removal

11.5.1.1.f. Revegetation

Methodologies for estimating GHG emissions and removals from RV activity are described in two cases: when RV activity is performed on the land where no land conversion has occurred (remaining land) and on the land where land conversion has occurred (Conversion Land).

a) Remaining land: Above-ground biomass, Below-ground biomass

Japan estimates the carbon stock change in above-ground biomass and below-ground biomass of tall trees planted in RV lands. Tall trees are consistent with the definition in "Standards for the quality and size of planted trees for the public (draft)[8]".

- ***Methodology***

$$\Delta C_{RVLB} = \sum_i \left(\Delta C_{LBG,i} - \Delta C_{LBL,i} \right)$$

$$\Delta C_{LBG,i} = \Delta B_{LBG,i}$$

$$\Delta B_{LBG,i} = \sum_j \left(NT_{i,j} \times C_{Ratei,j} \right)$$

[8] "Standards for the quality and size of planted trees for the public (draft)" was decided by the Ministry of Land, Infrastructure, Transport and Tourism in order to promote proper enforcement of projects such as greening in public spaces. Tall tree is defined in the standards as tree which reaches 3 ~ 5 m in height.

ΔC_{RVLB} : Annual carbon stock changes in living biomass in remaining RV land [t-C/yr]
ΔC_{LBG} : Annual carbon stock changes due to living biomass growth in remaining RV land [t-C/yr]
ΔC_{LBL} : Annual carbon stock changes due to living biomass loss in remaining RV land [t-C/yr]
ΔB_{LBG} : Annual living biomass growth in RV land [t-C/yr]
C_{Rate} : Annual living biomass growth rate per tree [t-C/tree/yr]
NT : Number of trees
i : Type of urban green facilities (Urban parks, Green areas on roads, Green areas at ports, Green areas around sewage treatment facilities, Green areas by greenery promoting systems for private green space, Green areas along rivers and erosion control sites, Green areas around public rental housing and Green areas around government buildings)
j : Tree species

- ***Parameters***[9]

➢ ***Urban parks***

Carbon stock changes due to the loss of living biomass in urban parks are assumed to be zero based on Tier 2b method in the *2006 IPCC Guidelines* (p. 8.7), because the average age of trees is found to be less than or equal to 30 years in the tree survey for sample urban parks[10] (*Parks, Green Spaces and Landscape Division, Ministry of Land, Infrastructure, Transport and Tourism (MLIT)*, 2014).

The annual living biomass growth of trees in urban parks is calculated by using the country-specific value for annual growth rate of living biomass per tree, which was developed by combining the default values (0.0033-0.0142 t-C/tree/yr) provided in the *2006 IPCC Guidelines* (p. 8.10, Table 8.2) and the country specific annual growth rates of living biomass for the trees in Japan (0.0204 for Japanese zelkova, 0.0103 for ginkgo, 0.0095 for bamboo-leaf oak and 0.0122 t-C/tree/yr for camphor tree) by taking into account the distribution ratio of tree species in sample urban parks[11]. The annual growth rates of living biomass for Japanese zelkova, ginkgo, bamboo-leaf oak and camphor tree are calculated by using the growth curve for each tree species (Matsue et al., 2009), which were developed based on the results of surveys conducted by the National Institute for Land and Infrastructure Management (NILIM) of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) and the average trunk diameter at breast height for each tree species (Parks and Green Spaces Division of the MLIT, 2005), which were determined from the results of surveys in urban parks.

For the ratio of above-ground biomass/below-ground biomass, the default value (root-to-shoot ratio: 0.26) provided in the *2006 IPCC Guidelines* (p. 8.9) is applied.

➢ ***Green areas on roads***

Carbon stock changes due to the loss of living biomass in green areas on roads are assumed to be zero, because the average age of trees is found to be less than or equal to 30 years for those trees planted in randomly extracted green areas on roads.

[9] The Tier 1b method described in the *2006 IPCC Guidelines* and the Tier 2b method with country-specific annual biomass growth rates are applied for the estimation of the annual growth rate of living biomass per tree. Japan will further improve the accuracy of this estimation.

[10] 129 samples were randomly extracted from the urban parks notified after 1 January 1990 and located in Kanagawa prefecture, which is located in Japan's typical climate zone and has various types of urban parks. In addition, the same survey was implemented in 3 urban parks in Chiba prefecture, which is located next to Kanagawa prefecture, in order to cover the park types that did not exist in Kanagawa prefecture.

[11] The distribution ratio of tree types was calculated by using tree registers and plantation maps for all urban parks in Kushiro city and Yubari city in Hokkaido and for 321 randomly extracted urban parks in the other prefectures.

The annual living biomass growth in green areas on roads is calculated by using the country-specific value for annual growth rate of living biomass per tree, which was developed by combining the default values and the annual growth rates of living biomass for the trees in Japan (4 species), which were also used for the urban parks, taking into account the distribution ratio of tree species indicated by the surveys in green areas on roads[12].

For the ratio of above-ground biomass/below-ground biomass, the same value used for urban parks is applied.

- ***Urban green areas other than Urban parks, Green areas on roads and Green areas by greenery promoting systems for private green space***

Carbon stock changes due to the loss of living biomass in these green areas are assumed to be zero, because the standard of planted trees, tree types and their distribution are applied in the same manner as in urban parks.

The annual living biomass growth and the ratio of above-ground biomass/below-ground biomass are the same parameters as for urban parks.

- ***Green areas by greenery promoting systems for private green space***

Carbon stock changes due to the loss of living biomass in these green areas are assumed to be zero, because the standard of planted trees is selected in the same manner as in urban parks and all facilities have been certified since 2002.

The annual living biomass growth and the ratio of above-ground biomass/below-ground biomass are the same parameters as for urban parks.

- ***Activity data***

- ***Urban parks***

The area of land remaining urban parks is calculated by multiplying the area of urban parks by the area ratio of land conversion for the whole country. The activity data for carbon stock changes in living biomass in urban parks is the number of tall trees planted in urban parks which is calculated by multiplying the area of urban parks obtained from the "Urban Parks Status Survey" by the number of tall trees per area (Hokkaido: 329.5 tree/ha, the other prefectures: 222.3 tree/ha). The number of tall trees per area is calculated based on the number of tall trees and the land areas of sample urban parks, whose sample number was intended to satisfy the significance level of 95%.[13]

[12] The distribution ratio of tree types is taken from the *Road Tree Planting Status Survey (The Street tree of Japan VI)*, which covered green areas on roads throughout Japan.

[13] The number of tall trees per area in urban parks was calculated by using data from tree registers and planting maps for randomly extracted 176 sample urban parks in Hokkaido and 321 sample urban parks in the other prefectures. For Hokkaido, the number of samples was not sufficient to satisfy the significant level of 95% because the tree register has not been developed completely.

Table 11-18 Area of urban parks which were not classified as forest land on 31 December 1989

At the end of FY2014

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2014	Area [ha]	Classified as RV land
Urban parks which have been notified since 1st January 1990 and whose establishment area is 500 m^2 or more	Forest	6.28%	3,683.81	No
	Non-forest	93.72%	55,020.73	Yes
	Total	100.00%	58,704.54	-

Table 11-19 Area of urban parks (remaining land / converted land)

At the end of FY2014

	Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Urban parks which have been notified since 1st January 1990 and whose establishment area is 500 m^2 or more (classified as RV land)	Converted (except land converted from forest land)	0.29%	161.42	37,838
	Remaining	99.71%	54,859.31	12,859,644
	Total	100.00%	55,020.73	12,897,482

- ***Green areas on roads***

The activity data (the number of tall trees) in "Remaining green areas on roads" is calculated by the following procedures.

1. The number of tall trees in all green areas on roads on 31 March 1990 and in the end of each corresponding fiscal year during the commitment period is estimated by using data from the "Road Tree Planting Status Survey" which have been implemented in FY1987, FY1992 and each corresponding fiscal year.
2. The number of tall trees planted after 1 April 1990 was calculated by subtracting the number for 31 March 1990 from the number for the end of each corresponding fiscal year (RV is an activity which takes place after 1 January 1990. However, Japan considers it an activity after 1 April 1990 because it is impossible to estimate the number of tall trees which have been planted between 1 April 1990 and 31 March 1990).
3. The number of tall trees calculated in step 2 is multiplied by the ratio of the number of tall trees planted on roads whose planted area is more than 500 m^2.
4. The number of tall trees calculated in step 3 is multiplied by the area ratio of green areas on roads, which were classified as "Forest land" on 31 December 1989.
5. The number of tall trees calculated in step 4 is multiplied by the area ratio of "Land remaining settlements".

Table 11-20 Area of green areas on roads which have been classified as RV

At the end of FY2014

	Area of green areas on roads per tall tree [ha/tree]	Number of planted tall trees [tree]			Area ratio of planted lands which are 500 m^2 or more [%]	Area ratio of land which was classified as forest land on 31st December 1989 [%]	Area of green areas on roads which was classified as RV land [ha]	Activity data [Number of tall trees]
		31st March 1990	31st March 2015	FY1990 - FY2014				
	a	b	c	c-b	d	e	a*(c-b)*d/100*(100-e)/100	(c-b)*d/100*(100-e)/100
General roads (managed by the MLIT, Prefectures, local authorities, public corporations)	0.006237	4,342,070	6,993,031	2,650,961	99.00%	6.28%	15,341	2,459,679
Expressway (managed by now-defunct public corporation)	0.000829903	1,096,380	8,484,858	7,388,478	100.00%	6.28%	5,747	6,924,838
Total	–	5,438,450	15,477,889	10,039,439	–	–	21,088	9,384,518

Table 11-21 Area of green areas on roads which have been classified as RV and activity data [number of tall trees] (remaining land / converted land)

At the end of FY2014

		Land-use category	Area ratio of land which has been converted in the current year	Activity data [Number of tall trees]	Area [ha]
Green areas on roads which have been notified since 1st January 1990 and whose establishment area is 500 m^2 or more (classified as RV land)		Converted	0.29%	27,532	61.87
		Remaining	99.71%	9,356,986	21,026.10
		Total	100.00%	9,384,518	21,087.96
	General roads	Converted	0.29%	7,216	45.01
		Remaining	99.71%	2,452,463	15,296.01
		Total	100.00%	2,459,679	15,341.02
	Expressway	Converted	0.29%	20,316	16.86
		Remaining	99.71%	6,904,523	5,730.08
		Total	100.00%	6,924,838	5,746.94

* "Converted": except land converted from forest land.

➢ *Green areas at ports*

The activity data for carbon stock changes in living biomass in green areas at ports is the number of tall trees planted in green areas at ports. The activity data is calculated by multiplying the service area obtained from complete census by the number of tall trees per unit area of urban parks (329.5 trees/ha for Hokkaido and 222.3 trees/ha for the other prefectures). These values were adopted by taking into account the similarities between the urban parks and the green areas at ports as mentioned above. All green areas at ports are located in "settlements" and judged not being classified as "Forest land" on 31 December 1989.

Table 11-22 Area of green areas at ports and activity data (remaining land / converted land)

At the end of FY2014

Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Converted	0.29%	5.21	1,184
Remaining	99.71%	1,769.72	402,444
Total	100.00%	1,774.93	403,628

➢ ***Green areas around sewage treatment facilities***

The area of land remaining green areas around sewage treatment facilities is calculated in the same manner as for urban parks. The activity data for carbon stock change in living biomass in green areas around sewage treatment facilities are obtained from the "Sewage Treatment Facility Status Survey" for each fiscal year during the commitment period. The number of tall trees planted in green areas around sewage treatment facilities is calculated by multiplying the greening areas by the number of tall trees per greening area (129.8 tree/ha for Hokkaido and 429.2 tree/ha for the other prefectures).[14] All green areas around sewage treatment facilities are located in "settlements".

Table 11-23 Area of green areas around sewage treatment facilities which were not classified as "Forest land" on 31 December 1989

At the end of FY2014

Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2014	Area (ha) (Green areas)	Classified as RV land
Forest	6.28%	42.99	No
Non-forest	93.72%	642.12	Yes
Total	100.00%	685.11	-

Table 11-24 Area and activity data of "Green areas around sewage treatment facilities" [number of tall trees] (remaining land / converted land)

At the end of FY2014

Land-use category	Area ratio of land has been converted for the current year	Area [ha] (Green areas)	Activity data [Number of tall trees]
Converted (except land converted from forest land)	0.29%	1.88	764
Remaining	99.71%	640.23	259,803
Total	100.00%	642.12	260,567

➢ ***Green areas by greenery promoting systems for private green space***

Activity data (the number of tall trees) is available for each facility. Therefore, the total number of tall trees is used as activity data.

[14] The number of tall trees per area for green areas around sewage treatment facilities was established by using data on the number of tall trees and greening areas measured in 59 green areas.

Table 11-25 Activity data and area of "Green areas by greenery promoting systems for private green space"

Certification year	Location	Area [m^2]	Breakdown of area [m^2]			Area	Activity data
			Ground	Roof	Wall	Wall green area by greenery promoting system for private green space [m^2]	Number of tall trees [tree]
2002	Minato-ku, Tokyo	17,244	1,314	2,042	106	3,356	335
2002	Minato-ku, Tokyo	19,708	3,285	736	0	4,021	147
2002	Minato-ku, Tokyo	52,766	10,679	0	0	10,679	672
2002	Minato-ku, Tokyo	84,780	8,846	9,386	0	18,232	813
2003	Minato-ku, Tokyo	5,519	1,374	280	0	1,654	167
2003	Osaka City	22,282	1,527	3,164	110	4,691	500
2005	Kawaguchi City	1,995	586	164	18	750	153
2006	Kyoto City	3,857	1,271	0	0	1,271	90
2006	Hiroshima City	4,453	130	783	0	913	1
2007	Hiroshima City	14,353	4,058	0	0	4,058	261
2007	Fukuoka City	5,689	773	799	0	1,572	19
2008	Ishikawa Prefecture	7,281	682	1,411	0	2,093	19
2009	Setagaya-ku, Tokyo	5,526	1,116	0	0	1,116	51
2009	Setagaya-ku, Tokyo	6,459	1,370	0	0	1,370	15
Total		251,912	37,011	18,765	234	55,776	3,243

* There were no areas certified in FY2010, FY2011, FY2012, FY2013 and FY2014.

- ***Green areas along rivers and erosion control sites***

The area of land remaining green areas along rivers and erosion control sites is calculated by multiplying the area of this green area by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is calculated by multiplying this area by the number of tall trees per area (Hokkaido: 1470.8 tree/ha, the other prefectures: 339.0 tree/ha).[15]

The green areas along rivers and erosion control sites exclude lands, which were classified as Forest land at the time of survey. Therefore, land conversion from Forest land is not taken into account for the estimation of activity data.

Table 11-26 Activity data and area of "Green areas along rivers and erosion control sites" (remaining land / converted land)

At the end of FY2014

	Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Green areas along rivers and erosion control sites which have been established since 1st January 1990 and whose establishment area is 500 m^2 or more (classified as RV land)	Converted (except land converted from forest land)	0.29%	5.03	2,783
	Remaining	99.71%	1,707.82	945,799
	Total	100.00%	1,712.85	948,582

- ***Green areas around government buildings***

The area of land remaining green area around government buildings is calculated by multiplying the area of this green area by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is calculated by multiplying this area by the number of tall trees per area (all prefecture: 108.8 tree/ha).[16]

[15] For green areas along rivers and erosion control sites, the number of tall trees was measured in approximately 95% of this green area. Based on these data, the number of planted trees per area was estimated in order to simplify the estimation of the number of tall trees in all green areas.

[16] For green areas around government buildings, the number of tall trees per area was estimated by dividing the number of

Table 11-27 Area of "Green areas around government buildings" which were not classified as "Forest land" on 31 December 1989

At the end of FY2014

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2014	Area [ha] (Green areas)	Classified as RV land
Green areas around government buildings which have been established since 1st January 1990 and whose establishment area is 500 m^2 or more	Forest	6.28%	20.11	No
	Non-forest	93.72%	300.35	Yes
	Total	100.00%	320.46	-

Table 11-28 Area and activity data of "Green areas around government buildings" (remaining land / converted land)

At the end of FY2014

	Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Green areas around government buildings which have been established since 1st January 1990 and whose establishment area is 500 m^2 or more (classified as RV land)	Converted (except land converted from forest land)	0.29%	0.88	96
	Remaining	99.71%	299.47	32,582
	Total	100.00%	300.35	32,678

- ***Green areas around public rental housing***

The area of land remaining green areas around public rental housing is calculated by multiplying the area of this green area by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is calculated by multiplying this area by the number of tall trees per area (all prefecture: 219.9 tree/ha).[17]

Table 11-29 Area of "Green areas around public rental housing" which were not classified as "Forest land" on 31 December 1989

At the end of FY2014

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2014	Area [ha] (Green areas)	Classified as RV land
Green areas around public rental housing which have been established since 1st January 1990 and whose establishment area is 500 m^2 or more	Forest	6.28%	156.84	No
	Non-forest	93.72%	2,342.59	Yes
	Total	100.00%	2,499.43	-

tall trees by the "total land area – building area" (these data were based on 30 facilities where planting maps were available). The common value is used for all prefectures, since the sample data were not sufficient enough to set values for Hokkaido and the other prefectures, respectively.

[17] For green areas around public rental housing, the number of tall trees per area was estimated for 33 facilities, where planting maps were available, by dividing the number of tall trees by the area "total land area – building area". The common value is used for all prefectures, since the sample data were not sufficient enough to set values for Hokkaido and the other prefectures, respectively.

Table 11-30 Area and activity data of "Green areas around public rental housing" (remaining land / converted land)

At the end of FY2014

	Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Green areas around public rental housing which have been established since 1st January 1990 and whose establishment area is 500 m^2 or more (classified as RV land)	Converted (except land converted from forest land)	0.29%	6.87	1,511
	Remaining	99.71%	2,335.71	513,623
	Total	100.00%	2,342.59	515,134

b) Remaining land: Dead wood

➢ ***Urban parks***

The number of tall trees per land area used in the estimation of activity data for living biomass includes trees which have died and have been complementary planted since the establishment of the park. Thus the carbon stock changes in dead wood are thought to be included in the carbon stock changes in living biomass. Therefore, this category is reported as "IE".

➢ ***Green areas on roads***

The number of tall trees used in the estimation of activity data for living biomass is surveyed every 5 years (implemented every year since 2007). These data include the effects of dead wood and complementary planting, thus the carbon stock change in dead wood is included in the carbon stock changes in living biomass. Therefore, this category is reported as "IE".

➢ ***Urban green facilities other than Urban parks and Green areas on roads***

These categories are reported as "IE" based on the same assumption as urban parks.

c) Remaining land: Litter

Carbon stock changes in litter are estimated for urban parks and green areas at ports.

● ***Methodology***

$$\Delta C_{RVLit} = \sum_i \left(A_i \times L_{it,i} \right)$$

ΔC_{RVLit} : Annual carbon stock changes in litter in remaining RV land [t-C/yr]
A : Area of remaining RV land [ha]
L_{it} : Annual carbon stock changes in litter per RV land [t-C/ha/yr]
i : Type of urban green facilities (Urban parks and Green areas at ports)

● ***Parameters***

➢ ***Urban parks and Green areas at ports***

For litter, Japan estimates carbon stock changes only in branches and leaves dropped naturally from tall trees. The carbon stock changes in litter per urban park area are calculated by using the annual accumulation of litter per tall tree (all prefectures: 0.0006 t-C/tree/yr) based on the results of a field survey in urban parks[18], the number of tall trees per area and the ratio of litter moved to off-site due to

[18] The annual accumulation of litter dropped naturally was measured for some tree types by using litter traps installed in Takino Suzuran Kyuryo National Government Park (Hokkaido) and Showa Kinen National Government Park (Tokyo). Litter is defined as branches and leaves dropped on the surface. In the selection of parks for the survey, large-sized and

management including cleaning (54.4%). As a result, carbon stock change in litter per urban park area is calculated to be 0.0882 t-C/ha/yr for Hokkaido and 0.0594 t-C/ha/yr for other prefectures. In addition, the carbon fraction in litter is assumed to be 0.4 t-C/t-d.m., which is a default value provided in the *2006 IPCC Guidelines* (p.8.21).

➢ ***Urban green facilities other than urban parks and green areas at ports***

Litter in these urban green facilities includes branches and leaves dropped naturally and dead roots. A part of the litter remains on-site and leads to an increase in carbon stocks, although other litter is moved to off-site due to management such as cleaning (such litter is dropped from trees planted after the establishment of green areas). Dead roots also lead to an increase in carbon stocks because they are not moved to off-site.

It is clear that the litter in the urban green facilities other than urban parks and green areas at ports because the input of fallen branches and leaves and dead roots into these facilities increases carbon stocks as mentioned above. However, it is difficult to accurately estimate the carbon stock changes in litter in these urban green facilities because it is difficult to obtain detailed information on various managements (such as cleaning). Therefore, as a conservative treatment, these sub-categories are not subject to reporting because they are not sources of GHGs.

● ***Activity data***

The activity data is the same as for living biomass.

d) Remaining land: Soils

Urban parks, for which the carbon stock changes in soils per area were determined, and green areas at ports, whose management practices are similar to those for urban parks, are the subject of estimation. In general, soils in RV land are not organic soils (peat soils and muck soils). Therefore, organic soils are reported as "NO", and only mineral soils are estimated.

● ***Methodology***

$$\Delta C_{RVSoils} = \sum_i \left(\Delta C_{Mineral,i} - L_{Organic,i} \right)$$

$$\Delta C_{Mineral,i} = A_i \times \Delta C_{Soil,i}$$

$\Delta C_{RVSoils}$: Annual carbon stock changes in soils in remaining RV land[19] [t-C/yr]
$\Delta C_{Mineral}$: Annual carbon stock changes in mineral soils in RV land [t-C/yr]
$L_{Organic}$: Annual carbon stock changes in organic soils in RV land (=0) [t-C/yr]
A : Area of remaining RV land [ha]
ΔC_{Soil} : Annual carbon stock changes in soils per area of remaining RV land [t-C/ha/yr]
i : Type of urban green facilities (Urban parks and Green areas at ports)

intensively managed national government parks in which continuous monitoring is available and different types of trees have been planted are considered to meet the measurement requirements. In addition, it is also considered that the distribution of tree types differs between Hokkaido and other prefectures. Therefore, Japan selected two parks for the survey, one in Hokkaido and the other in a typical climate zone excluding Hokkaido.

[19] Soil organic carbon pools are the subject of estimation of carbon stock changes in soils in RV land.

- ***Parameters***

➢ ***Urban parks and Green areas at ports***

Carbon stock changes in soils per area of RV land are estimated based on the results of surveys[20] conducted in urban parks which have been established within 30 years (1.28t-C/ha/yr for 0~20 years and 1.38t-C/ha/yr for 21~30 years) (Tonosaki et al., 2013; Parks, Green Spaces and Landscape Division, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 2015)[21].

This value is applicable to land, which is the subject of revegetation activity and was established within 30 years, because the value is based on the results of surveys conducted in urban parks which have been established within 30 years.

➢ ***Urban green facilities other than Urban parks and Green areas at ports***

It is assumed that the patterns of carbon stock changes in soils in these urban green facilities are similar to those in urban parks, because planting, establishment and management practices are implemented in a similar way. The expressway slopes, where different plantation practices are applied, are assumed to be a sink, because field surveys have revealed that the carbon stocks keep increasing for at least 20 years after establishment.

However, it is difficult to accurately estimate the carbon stock changes in soils in these urban green facilities because available data are not sufficient to estimate carbon stock changes in soils in these facilities. Therefore, as a conservative treatment, these sub-categories are not subject to reporting because they are not sources of GHGs. The estimation for urban green facilities other than urban parks and green areas at ports will be further considered in the future.

- ***Activity data***

The area is as obtained for estimating the activity data for living biomass.

e) Remaining land: Other gases

1) Direct and indirect N_2O emissions from N fertilization

It is assumed that the volume of nitrogen-based fertilizer applied to urban parks is included in the demand for nitrogen-based fertilizers in the Agriculture sector, although fertilization in urban parks has been conducted in Japan. Therefore, these sources have been reported as "IE".

2) N_2O and CH_4 emissions from drainage of soils

Because soil drainage activity for organic soils in RV does not occur in Japan, this category is reported

[20] Soil carbon stocks (at 30 cm depth) were measured for areas with different types of vegetation cover in urban parks (planted: 31 areas, lawn: 29 areas, bare: 21 areas), which are located in Tokyo and were established in different years.

[21] Since urban parks are generally established by turning entire sites into urban parks, soil carbon stocks within the site immediately after establishment are assumed to be uniform irrespective of previous types of vegetation cover. The soil carbon stocks of the area, where basically carbon is not supplied by plants (bare area), are assumed to be the same as soil carbon stocks of sites immediately after conversion. Based on the soil carbon stocks in the areas with different types of vegetation cover (planted, lawn and bare) in urban parks, which were established in different years, "carbon accumulation rates in planted areas" and "carbon accumulation rates in lawn areas" are calculated:

- Carbon accumulation rates in planted areas = "Difference in soil carbon stocks between planted and bare areas" / "Average years after establishment of surveyed planted areas"
- Carbon accumulation rates in lawn areas = "Difference in soil carbon stocks between lawn and bare areas" / "Average years after establishment of surveyed lawn areas"

Furthermore, changes in soil carbon stocks per area are determined by taking the weighted average based on the typical area ratio among planted, lawn and bare sites in urban parks. The soil carbon stocks of bare area are about 38 t-C/ha when converted from the sample data.

as "NO".

3) N_2O emissions from N mineralization/immobilization due to carbon loss/gain associated with land-use conversions and management change in mineral soils

Since soil carbon stock changes in RV are reported to be in increases, theses carbon pools are not sources of GHGs, according to method under Tier 2, N_2O emissions from immobilization associated with gain of soil organic matter were not estimated. Therefore, N_2O emissions in this subcategory is reported as "NA".

4) Biomass burning

In settlements subjected to RV activities, burning of residues is essentially prohibited by the Law for Waste Treatment and Cleaning. In addition, wild fires do not usually occur in lands subjected to RV activities because these lands are managed. Therefore, biomass burning activities which lead to carbon emissions do not occur and Japan reports this category as "NO".

f) Land converted from other land-use categories: Above-ground biomass, Below-ground biomass

- ***Methodology***

For RV activities, land conversion occurs due to the establishment or building of "facilities" and all living biomass is basically replaced in one year (In the case of urban parks converted from cropland, new planting in urban parks is carried out after removal of trees in cropland).

In Japan's basic estimation principles for land converted to RV land, the facilities established newly by land conversion in the reporting year are defined as "Land converted to RV land". The estimation methods are shown below.

$$\Delta C_{RVLUC} = \sum_i \left\{ A_i \times \left(C_{AfterLBi} - C_{BeforeLBi} \right) + \left(\Delta C_{RVLUCGi} - \Delta C_{RVLUCLi} \right) \right\}$$

$$\Delta C_{RVLUCGi} = \Delta B_{RVGi}$$

$$\Delta B_{RVGi} = \sum_j \left(NT_{i,j} \times C_{Ratei,j} \right)$$

ΔC_{RVLUC} *: Annual carbon stock changes in living biomass in converted RV land [t-C/yr]*

A : *Area of converted RV land [ha/yr]*

$C_{AfterLB}$: Carbon stocks in living biomass immediately following land conversion [t-C/ha]

$C_{BeforeLB}$: Carbon stocks in living biomass immediately before land conversion [t-C/ha]

ΔC_{RVLUCG} : Annual carbon stock changes due to living biomass growth in converted RV land [t-C/yr]

ΔC_{RVLUCL} : Annual carbon stock changes due to living biomass loss in converted RV land [t-C/yr]

ΔB_{RVG} : Annual biomass growth in RV land [t-C/yr]

C_{Rate} : Annual living biomass growth per tree [t-C/tree/yr]

NT : Number of trees

i : Type of urban green facilities (Urban parks, Green areas on roads, Green areas at ports, Green areas around sewage treatment facilities, Green areas by greenery promoting systems for private green space, Green areas along rivers and erosion control sites, Green areas around public rental housing and Green areas around government buildings)

j : Tree species

- ***Parameters***

➢ ***Urban parks***

The carbon stocks in living biomass immediately before conversion [t-C/ha] are the same as those for grassland, cropland, wetlands and other land. The carbon stocks in living biomass immediately following conversion are assumed to be zero (When urban parks classified as RV land were established, planting activities occurred and living biomass was stocked. Japan assumes that these biomass stocks are zero because they were carried from other fields and they have not grown by the RV activities). In addition, it is assumed that living biomass before conversion is emitted due to the establishment of RV land. The other parameters are assumed to be the same as the ones for "Remaining urban parks".

➢ ***Urban green facilities other than Urban parks***

The carbon stocks in living biomass immediately before and after conversion [t-C/ha] are the same as those for urban parks converted from other land uses.

The other parameters are assumed to be the same as the ones for "Remaining green area on roads", "Remaining green area at ports", "Remaining green area around sewage treatment facilities", "Remaining green area along rivers and erosion control sites", "Remaining green area around public rental housing" and "remaining green area around government buildings".

- ***Activity data***

➢ ***Urban parks***

The area of land converted to urban parks is calculated by multiplying the area of urban parks by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining urban parks".

Table 11-31 Area of "Urban parks" and activity data (remaining land /converted land)

At the end of FY2014

	Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Urban parks which have been notified since 1st January 1990 and whose establishment area is 500 m^2 or more	Remaining land	99.71%	54,859.31	12,859,644
	Cropland	0.25%	136.14	31,913
	Grassland	0.05%	25.27	5,924
	Wetlands	IE	IE	IE
	Other land	IE	IE	IE
	Total	100.00%	55,020.73	12,897,481

➢ ***Green areas on roads***

The area of land converted to green area on roads is calculated by multiplying the area of green areas on roads by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green area on roads".

Table 11-32 Area of "Green areas on roads" and activity data for each land-use category

At the end of FY2014

	Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Green areas on roads which have been notified since 1st January 1990 and whose establishment area is 500 m^2 or more	Remaining	99.71%	21,026.10	9,356,986
	Cropland	0.25%	52.18	23,221
	Grassland	0.05%	9.69	4,311
	Wetlands	IE	IE	IE
	Other land	IE	IE	IE
	Total	100.00%	21,087.96	9,384,518

- ***Green areas at ports***

The area of land converted to green areas at ports is calculated by multiplying the service area of green areas at ports by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green areas at ports".

Table 11-33 Area of "Green areas at ports" and activity data for each land-use category

At the end of FY2014

Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Remaining land	99.71%	1,769.72	402,444
Cropland	0.25%	4.39	999
Grassland	0.05%	0.82	185
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	1,774.93	403,628

- ***Green areas around sewage treatment facilities***

The area of land converted to green areas around sewage treatment facilities is calculated by multiplying the green areas around sewage treatment facilities by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green area around sewage treatment facilities".

Table 11-34 Area of "green areas around sewage treatment facilities" and activity data for each land-use category

At the end of FY2014

Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Remaining land	99.71%	640.23	259,803
Cropland	0.25%	1.59	645
Grassland	0.05%	0.29	120
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	642.12	260,568

➢ ***Green areas along rivers and erosion control sites***

The area of land converted to green areas along rivers and erosion control sites is calculated by multiplying the planted land area by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green area along rivers and erosion control sites".

Table 11-35 Area of "green areas along rivers and erosion control sites" and activity data for each land-use category

At the end of FY2014

Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Remaining land	99.71%	1,707.82	945,799
Cropland	0.25%	4.24	2,347
Grassland	0.05%	0.79	436
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	1,712.85	948,582

➢ ***Green areas around government buildings***

The area of land converted to green areas around government buildings is calculated by multiplying the "total land area – building area" by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green area around government buildings".

Table 11-36 Area of "green areas around government buildings" and activity data for each land-use category

At the end of FY2014

Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Remaining land	99.71%	299.47	32,582
Cropland	0.25%	0.74	81
Grassland	0.05%	0.14	15
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	300.35	32,678

➢ ***Green areas around public rental housing***

The area of land converted to green areas around public rental housing is calculated by multiplying the "total land area – building area" by the area ratio of land conversion for the whole country. The activity data for living biomass (the number of tall trees) is estimated in the same manner as for "remaining green area around public rental housing".

Table 11-37 Area of "green areas around public rental housing" and activity data for each land-use category

At the end of FY2014

Land-use category before conversion	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Remaining land	99.71%	2,335.71	513,623
Cropland	0.25%	5.80	1,275
Grassland	0.05%	1.08	237
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	2,342.59	515,135

g) Land converted from other land use categories: Dead wood

When a RV activity following land-use conversion is implemented, dead wood is removed off-site and supplemental planting is implemented before conversion because almost all of such lands are managed and trees are assumed to be "property". Therefore, dead wood is not left on the ground immediately before land-use conversion. The carbon stocks in dead wood immediately after conversion are assumed to be zero, the same as living biomass. Therefore, the carbon stocks in dead wood before and after conversion are assumed to be zero.

The carbon stocks in dead wood accumulated for a year after conversion are reported as "IE", the same as for "Remaining land".

h) Land converted from other land-use categories: Litter

Likewise the "remaining land", Japan estimates carbon stock changes in litter in urban parks and green areas at ports only. The other urban green facilities (green areas on roads, green areas around sewage treatment facilities, green areas along rivers and erosion control sites, green areas around public rental housing and green areas around government buildings) are not the subject of estimation and are not reported (NR) , since these facilities are not net sources.

- ***Methodology***

$$\Delta C_{LUCRVLit} = \sum_i \left\{ A_i \times \left(C_{AfterLiti} - C_{BeforeLiti} \right) + A_i \times Lit_i \right\}$$

$\Delta C_{LUCRVLit}$: Annual carbon stock changes in litter in land converted to RV land [t-C/yr]
$C_{AfterLit}$: Carbon stocks in litter immediately following land conversion [t-C/ha]
$C_{BeforeLit}$: Carbon stocks in litter immediately before land conversion [t-C/ha]
A : Area of converted RV land [ha/yr]
Lit : Annual carbon stock changes in litter per area of RV land [t-C/ha/yr]
i : Types of urban green facilities (Urban parks and Green areas at ports)

- ***Parameters***

➢ ***Urban parks and Green areas at ports***

When urban parks are converted from cropland, grassland or wetlands, soils before conversion are not moved to off-site and in general, these soils are used continuously after conversion or covered by

additional soils. Therefore, litters and dead roots accumulated before conversion do not decrease due to the land-use conversion.

In addition, litter in urban parks immediately following conversion is very little, because the parks are newly planted. Therefore, carbon stock changes in litter due to land conversion are assumed to be zero.

The amount of carbon in litter accumulated for a year after conversion is estimated in the same manner as for "Remaining urban parks".

➢ ***Urban green facilities other than Urban parks and Green areas at ports***

The carbon stock changes in litter due to land-use conversion are assumed to be zero for the same reasons as for urban parks. With respect to after conversion, it is clear that the litter in the urban green facilities other than urban parks and green areas at ports because the input of fallen branches and leaves and dead roots into these facilities increases carbon stocks likewise the "remaining green area on roads", "remaining green area around sewage treatment facilities", "remaining green area along rivers and erosion control sites", "remaining green area around public rental housings" and "remaining green area around government buildings" mentioned above. However, it is difficult to accurately estimate the carbon stock changes in litter in these urban green facilities because it is difficult to obtain detailed information on various managements (such as cleaning). Therefore, as a conservative treatment, these sub-categories are not subject to reporting because they are not sources of GHGs.

- ***Activity data***

The activity data is the same as for living biomass.

i) Land converted from other land-use categories: Soils

Likewise the "remaining land", urban parks and green areas at ports, whose management practices are similar to those in urban parks, are the only subject of estimation.

- ***Methodology***

$$\Delta C_{LUCRVSoils} = \sum_i \left(\Delta C_{LUCMineral,i} - L_{LUCOrganic,i} \right)$$

$$\Delta C_{LUCMineral,i} = \Delta A_i \times \left(C_{AfterSoil} - C_{BeforeSoil} \right) + A_i \times \Delta C_{soil,i}$$

$\Delta C_{LUCRVSoils}$: Annual carbon stock changes in soils in RV land following land-use conversion [t-C/ha]
$\Delta C_{LUCMineral}$: Annual carbon stock changes in mineral soils in RV land following land conversion [t-C/ha]
$L_{LUCOrganic}$: Annual carbon stock changes in organic soils in RV land following land conversion (=0) [t-C/ha]
ΔA : Area of land converted to RV land within a year [ha/yr]
A : Area of land converted to RV land [ha]
$C_{AfterSoil}$: Soil carbon stocks immediately after land-use conversion [t-C/ha]
$C_{BeforeSoil}$: Soil carbon stocks before land-use conversion [t-C/ha]
ΔC_{Soil} : Annual carbon stock changes in soils per RV land area [t-C/ha/yr]
i : Types of urban green facilities (urban parks and green areas at ports)

- ***Parameters***

➢ ***Urban parks and Green areas at ports***

As mentioned in the section for litter, when urban parks are converted from cropland, grassland or wetlands, soils before conversion are almost never moved to off-site (even if moved to off-site, carbon in these soils are not emitted due to combustion). In general, these soils are used after conversion continuously or covered by additional soils.

Therefore, soil carbon stocks do not change due to land-use conversion (the carbon stocks may increase due to additional soils. However, Japan assumes that soil carbon stocks do not change because additional soils do not lead to carbon sequestration from the atmosphere).

Carbon stock changes in soils within a year after conversion is estimated in the same manner as for the remaining urban parks and green areas at ports.

➢ ***Urban green areas other than Urban parks and Green areas at ports***

The urban green facilities other than urban parks and green areas at ports are not sources of GHGs because of the same reasons as for the "Land converted to urban parks". Therefore, as a conservative treatment, these sub-categories are not subject to reporting because they are not sources of GHGs.

- ***Activity data***

The area is as used for living biomass.

j) Land converted from other land-use categories: Other gases

For reporting each GHG emission, the same way as the RV remaining RV is used.

k) Results

Table 11-38 Emissions and removals from RV activity

		1990	2013	2014
		[kt-CO_2]	[kt-CO_2]	[kt-CO_2]
RV		-78.79	-1,206.47	-1,224.79
	Above-ground biomass	-47.14	-736.95	-746.01
	Below-ground biomass	-12.26	-191.61	-193.96
	Dead wood	IE	IE	IE
	Litter	-0.92	-12.77	-13.04
	Soils	-18.46	-265.14	-271.79
	Other gases	IE,NA,NO	IE,NA,NO	IE,NA,NO

* CO_2) +: Emission, -: Removal

For RV activities, various parameters (annual living biomass growth of trees, number of tall trees per area, etc.) which corresponding to specific characteristic of types of urban green facilities (sub-categories) and climatic division (Hokkaido, areas other than Hokkaido), have been applied.

Hence, the total removals per unit of area in the revegetation in each year were not the same because distribution ratios for the sub-categories in each year have changed.

11.5.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4

Some carbon pools under RV activities (litter and soils: green areas on roads, green areas around sewage treatment facilities, green areas by greenery promoting systems for private green space, green areas along river and erosion control sites, green areas around public rental housing and green areas around government buildings) are not included in the reporting. Some intermediate results of the ongoing research project relating to RV land by the MLIT show a clear tendency that those carbon pools have been increasing although more research and analysis are necessary to quantify carbon stock changes in these carbon pools (Handa et al., 2008). This does not lead to over-estimation of removals because these carbon pools are not sources of GHGs, although further information and data are needed for estimating carbon stock changes in these carbon pools.

Carbon pools of dead wood and litter in CM and in GM are not included in the reporting. As described in the relevant sections, carbon stock changes in dead and litter in CM and in GM were estimated as zero. This does not lead to over-estimation of removals because theses carbon pools are not sources of GHGs.

11.5.1.3. Information relating to exclusion of emission from natural disturbance

Japan does not apply to exclusion of emissions from natural disturbance.

11.5.1.4. Information relating to Harvest Wood Product (HWP)

As described in 11.5.1.1.c), for HWP of the reporting of LULUCF under the Convention, carbon stock change in sawnwood, wooden board, and plywood used in buildings were estimated by using Tier 3 country-specific method. As for wood use other than buildings and paper and paperboard, were calculated by using Tier 2 method described in the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*. The estimation equation, and used parameters and activity data are the same as section 6.11 in Chapter 6 in this NIR.

In the report under the Kyoto Protocol, the values were estimated by deducting the HWP resulting from deforestation as instantaneous oxidation, and reference level of HWP (see 11.7.3.3) which was established as technical adjustments, from the values reported to the Convention, in accordance with the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*.

11.5.1.5. Information on whether or not indirect and natural GHG emissions and removals have been factored out

Japan does not factor out indirect, natural and pre-1990 effects specified in paragraph 3 in the annex II to decision 2/CMP.8 in estimating emissions/removals from activities under Articles 3.3 and 3.4.

11.5.1.6. Changes in data and methods since the previous submission (recalculations)

■ ***Revisions of AR and D areas***

In this submission, Japan revised the ARD ratio. As a result, the AR and D areas were recalculated. Due to this revision, carbon stock changes in above-ground biomass, below-ground biomass, litter, dead wood and mineral soils in AR, D and FM for FY 2013 were also recalculated.

In addition, D areas and correspondent Article 3.4 areas which are subject to D and CM, GM, RV

activities were recalculated due to this revision; hence, the areas of CM, GM and RV were also recalculated. As a result, carbon stock changes in all carbon pools in CM, GM and RV were also recalculated.

Moreover, ratios of disaggregating damaged timber volume from national to prefecture were estimated by utilizing AR area. Hence, CH_4 and N_2O emissions from biomass burning in AR was recalculated because of revision of the ratios of disaggregating amount of damaged timber volume due to revision of AR area.

- ***Revision of annual amount of loss of soil carbon of N mineralized in FM***

Since the amount of loss of soil carbon of N mineralized in FM have been revised, N_2O emission from N mineralization associated with loss of soil organic matter in FM was recalculated.

- ***Change in N_2O emission from N mineralization due to carbon loss associated with land-use conversions and management change in mineral soil in CM and in GM***

Since the emission factor had been updated, N_2O emissions from mineral soil in CM and in GM were recalculated for FY1990 and FY2013.

- ***Changes in average carbon stock in soil per unit area in urban parks***

Carbon stock in soil per unit area in urban parks was estimated within 20 years since establishment of the park. However, it has been demonstrated that carbon stock changes in soil in plating land occur even in the period of establishment after 21 to 30 years. Therefore, the value is applicable to land, which is the subject of revegetation activity and was established within 30 years. As a result, removals of soils in RV for FY1990 and FY2013 were recalculated.

- ***Emissions/removals of living biomass, litter and soils in RV land***

Since the activity data were updated due to update of land-use conversion rates, the emissions/removals in RV for FY1990 and FY2013 were recalculated.

- ***Revisions of activity data used for calculating carbon stock change in HWP***

In this submission, recalculation was carried out based on reviewing the activity data to reflect the actual condition.

11.5.1.7. Uncertainty estimates

The uncertainty of the total emissions/removals from activities under Articles 3.3 and 3.4 in 2014 has been assessed to be -16% to +16%.

See relevant sections of chapters 6 and 11 for uncertainties of respective parameters of the LULUCF sector. Specifically, see tables 11-40 to 11-43 below for detailed information on disaggregated uncertainties on emission factors and activity data used for estimating GHG emissions from and removals by each KP-LULUCF activity.

Table 11-39 Uncertainty of emissions/removals from activities under Articles 3.3 and 3.4 of KP

Greenhouse gas source and sink activities	GHGs	Emissions/Removals [kt CO_2eq.]		Emissions/Removals Uncertainty [%]		Emissions/Removals Uncertainty as % of net removals [%]	
			%	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.3 activities Afforestation and Reforestation	CO_2, N_2O, CH_4	-531	-1%	-33%	33%	0%	0%
Article 3.3 activities Deforestation	CO_2, N_2O, CH_4	2,134	5%	-19%	19%	1%	-1%
Article 3.4 activities Forest management	CO_2, N_2O, CH_4	-50,033	-110%	-14%	14%	-16%	16%
Article 3.4 activities Cropland management	CO_2, N_2O, CH_4	4,328	10%	-33%	33%	3%	-3%
Article 3.4 activities Grazing land management	CO_2, N_2O, CH_4	-90	0%	-15%	15%	0%	0%
Article 3.4 activities Revegetation	CO_2, N_2O, CH_4	-1,225	-3%	-33%	33%	-1%	1%
Total		-45,417	-100%	-16%	16%		

11.5.1.7.a. Uncertainties of emissions/removals of afforestation/reforestation activities

Uncertainties of emissions/removals in living biomass resulting from AR activities were estimated by applying Tier 1 – error propagation equation – based on uncertainties in accuracy of AR area identification (activity data), in estimation of carbon stock changes in living biomass in forest land, and in carbon stocks before land conversion. Uncertainties of emissions/removals in litter, dead woods and soils were estimated by applying Monte Carlo Analysis in the CENTURY-jfos Model. As a result, the uncertainty of emissions/removals from AR activities in 2014 has been assessed to be -33% to +33%.

Table 11-40 Uncertainty of emissions and removals from afforestation and reforestation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [kt CO_2 eq.]	AD Uncertainty		EF/RF Uncertainty [%]		Combined Uncertainty [%]		Combined Uncertainty as % of emissions/ removals [%]	
					(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.3 activities Afforestation and Reforestation	Change in carbon pool reported											
		Above-ground biomass	CO_2	-303	-12%	12%	-43%	43%	-45%	45%	-32%	32%
		Below-ground biomass	CO_2	-78	IE	IE	IE	IE	IE	IE	IE	IE
		Litter	CO_2	-32	-	-	-	-	-51%	51%	-3%	3%
		Dead wood	CO_2	-108	-	-	-	-	-22%	22%	-4%	4%
		Soil	CO_2	-10	-	-	-	-	-20%	20%	0%	0%
		Harvested wood products (HWP)	CO_2	NO	-	-	-	-	-	-	-	-
	Greenhouse gas sources reported			0	0%	0%	0%	0%	0%	0%	0%	0%
		Fertilization	N_2O	IE	-	-	-	-	-	-	-	-
		N_2O emissions from drainage of soils	N_2O	NO	-	-	-	-	-	-	-	-
		N_2O emissions from N mineralization associated with loss of soil organic	N_2O	NA	-	-	-	-	-	-	-	-
		Biomass burning	CO_2	IE	IE	IE	IE	IE	IE	IE	-	-
			CH_4	0	-	-	-	-	-51%	51%	0%	0%
			N_2O	0	-	-	-	-	-53%	53%	0%	0%
	Total			-531					-33%	33%		

11.5.1.7.b. Uncertainties of emissions/removals of deforestation activities

Uncertainties of emissions/removals in living biomass resulting from D activities were estimated, as same as AR activities, by applying Tier 1 – error propagation equation – based on uncertainties in

accuracy of D area identification (activity data), in estimation of carbon stock changes in living biomass in forest land, and in growth of living biomass after land conversion. Uncertainties of emissions/removals in litter, dead woods and soils were estimated by applying Monte Carlo Analysis in the CENTURY-jfos Model. As a result, the uncertainty of emissions/removals from D activities in 2014 has been assessed to be -19% to +19%.

Table 11-41 Uncertainty of emissions and removals from deforestation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [kt CO_2 eq.]	AD Uncertainty [%]		EF/RF Uncertainty [%]		Combined Uncertainty [%]		Combined Uncertainty as % of emissions/ removals [%]	
					(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.3 activities Deforestation	Change in carbon pool reported											
		Above-ground biomass	CO_2	1,044	-12%	12%	-26%	26%	-28%	28%	-17%	17%
		Below-ground biomass	CO_2	265	IE	IE	IE	IE	IE	IE	IE	IE
		Litter	CO_2	191	-	-	-	-	-51%	51%	-5%	5%
		Dead wood	CO_2	473	-	-	-	-	-22%	22%	-5%	5%
		Soil	CO_2	141	-	-	-	-	-20%	20%	-1%	1%
		Harvested wood products (HWP)	CO_2	IO	-	-	-	-	-	-	-	-
	Greenhouse gas sources reported			0	0%	0%	0%	0%	0%	0%	0%	0%
		Fertilization	N_2O	IE	-	-	-	-	-	-	-	-
		Drainage of soils under forest management	N_2O	NO	-	-	-	-	-	-	-	-
		N_2O emissions from N mineralization associated with loss of soil organic matter	N_2O	16	-	-	-	-	-75%	202%	-1%	2%
		Indirect N_2O emissions	N_2O	4	-	-	-	-	-119%	288%	0%	0%
		Biomass burning	CO_2	NO	-	-	-	-	-	-	-	-
			CH_4	NO	-	-	-	-	-	-	-	-
			N_2O	NO	-	-	-	-	-	-	-	-
	Total			2,134					-19%	19%		

11.5.1.7.c. Uncertainties of emissions/removals of forest management activities

Uncertainties of emissions/removals in living biomass resulting from FM activities were estimated by applying Tier 1 – error propagation equation – based on uncertainties in data on forest areas and FM ratio and in estimation of carbon stock changes in living biomass in forest land. Uncertainties of emissions/removals in litter, dead woods and soils were estimated by applying Monte Carlo Analysis in the CENTURY-jfos Model. As a result, the uncertainty of emissions/removals from FM activities in 2014 has been assessed to be -14% to +14%.

Table 11-42 Uncertainty of emissions/removals from forest management activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [kt CO_2 eq.]	AD Uncertainty [%]		EF/RF Uncertainty [%]		Combined Uncertainty [%]		Combined Uncertainty as % of emissions/ removals [%]	
					(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.4 activities Forest management	Change in carbon pool reported											
		Above-ground biomass	CO_2	-39,898	-12%	12%	-8%	8%	-14%	14%	-14%	14%
		Below-ground biomass	CO_2	-10,082	IE	IE	IE	IE	IE	IE	IE	IE
		Litter	CO_2	-225	-	-	-	-	-51%	51%	0%	0%
		Dead wood	CO_2	2,114	-	-	-	-	-22%	22%	1%	-1%
		Soil	CO_2	-1,438	-	-	-	-	-20%	20%	-1%	1%
		Harvested wood products (HWP)	CO_2	-621	-	-	-	-	-30%	30%	0%	0%
	Greenhouse gas sources reported											
		Fertilization	N_2O	1	-	-	-	-	-31%	31%	0%	0%
		Drainage of soils under forest management	N_2O	NO	-	-	-	-	0%	0%	-	-
		N_2O emissions from N mineralization associated with loss of soil organic matter	N_2O	81	-	-	-	-	-75%	202%	0%	0%
		Indirect N_2O emissions (N fertilization)	N_2O	0	-	-	-	-	-143%	493%	0%	0%
		Indirect N_2O emissions (N mineralization)	N_2O	18	-	-	-	-	-119%	493%	0%	0%
		Biomass burning	CO_2	IE	IE	IE	IE	IE	IE	IE	-	-
			CH_4	16	-	-	-	-	-29%	29%	0%	0%
			N_2O	1	-	-	-	-	-32%	32%	0%	0%
	Total			-50,033					-14%	14%		

11.5.1.7.d. Uncertainties of emissions/removals of cropland management

For the uncertainties of activity data for living biomass in orchards, the uncertainties of statistics and the default values given in the *2006 IPCC Guidelines* are applied. For the uncertainties of mineral soil, the comparison of simulation results and actual measurement, when both input values and actual measurement values of mineral soils are available, revealed that the uncertainty due to model structure was estimated about 10%. The uncertainties caused by input values have not been quantified yet and remain as an issue to be solved. For the uncertainties of organic soil, the uncertainties of statistical data and default values given in the *Wetlands Guidelines* are used. As a result, the uncertainty of emissions and removals accompanied by cropland management was evaluated to be -33% to +33%.

11.5.1.7.e. Uncertainties of emissions/removals of grazing land management

The method used is omitted because uncertainties of carbon stock change in mineral soil are the same as CM. Uncertainties of existing statistics and the default values described in the *Wetlands Guidelines* were applied to the estimation of CO_2 emissions from organic soil. As a result, the uncertainty of emissions and removals accompanied by grazing land management was evaluated to be -15% to +15%.

11.5.1.7.f. Uncertainties of emissions/removals of revegetation activities

Uncertainties of emissions/removals resulting from RV activities were estimated by following processes of estimating carbon stock changes in 8 sub-categories. First, uncertainties of each carbon pool (living biomass, litter and soils) in the 8 sub-categories were estimated by combining uncertainties of parameters and activity data (areas and the number of tall trees) used for estimating carbon stock changes. Next, an uncertainty of emissions/removals resulting from RV activities as a whole was estimated by applying Tier 1 – error propagation equation – based on the carbon stock changes in the 8 sub-categories. As a result, the uncertainty of emissions/removals from RV activities in 2014 has been assessed at -33% to +33%.

Table 11-43 Uncertainty of emissions/removals from revegetation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [kt CO_2 eq.]	AD Uncertainty [%]		EF/RF Uncertainty [%]		Combined Uncertainty [%]		Combined Uncertainty as % of emissions/ removals [%]	
					(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]	(-)[%]	(+)[%]
Article 3.4 activities	Change in carbon pool reported											
		Above-ground biomass	CO_2	-746	-	-	-	-	-41%	41%	-32%	32%
		Below-ground biomass	CO_2	-194	IE	IE	IE	IE	IE	IE	IE	IE
Revegetation		Litter	CO_2	-13	-	-	-	-	-61%	61%	-1%	1%
		Dead wood	CO_2	IE	-	-	-	-	-	-	-	-
		Soil	CO_2	-272	-	-	-	-	-38%	38%	-8%	8%
	Total			-1,225					-33%	33%		

11.5.1.8. Information on other methodological issues (methods dealing with the effects of natural disturbances[22])

11.5.1.8.a. Afforestation/Reforestation and Deforestation

The effects of natural disturbances have been reflected in forest resources data when Forest Registers

[22] Including fires, windstorms, insects, droughts, flooding and ice storms, etc.

are updated every 5 years in each planning area.

11.5.1.8.b. Forest Management

The effects of natural disturbances have been reflected in forest resources data when Forest Registers are updated every 5 years in each planning area.

11.5.1.8.c. Revegetation

It is considered that windstorms, floods and insects are natural disturbances which have a considerable impact on carbon stock changes in RV land. However, all land classified as RV is under human-induced management by administration etc. In addition, when tall trees disappear and outflow of soils occur in RV land located in settlements, the business budget is often appropriated and urgent restoration measures are administered from the viewpoint of safety and view.

Consequently, the effects of natural disturbances are not considered in the estimation because it looks that carbon stocks do not change. Furthermore, carbon stock change due to post-disaster restoration practices which are not implemented in the year when the disaster occurred does not lead to double-counting because it is not considered in this reporting.

11.5.1.9. The year of the onset of an activity, if after 2013

In this submission, all units of land and lands which start to be subject to activities under Article 3.3, Article 3.4 and any elected activities under Article 3.4 until 2014 are reported. The emissions and removals from the units of land and the lands which start to be subject to the activities in 2014 for the first time are not included in the calculated emissions and removals in 2013. The areas of such lands are shown below.

Table 11-44 Areas of afforestation/ reforestation, deforestation and forest management

Area of activities	Afforestation/Reforestation [kha]	Deforestation [kha]	Forest Management [kha]		
			Ikusei-rin forest	Tennensei-rin forest	Total
FY1990-2014	35.5	358.1	8,707	7,335	16,042
(FY2014)	—	7.3	—	—	—

Table 11-45 Areas of revegetation

Categories	Urban parks [ha]	Green areas on roads [ha]	Green areas at ports [ha]	Green areas around sewage treatment facilities [ha]	Green areas by greenery promoting systems for private green space [ha]
FY1990	3,737	1,620	198	44	0
FY1990-FY2014	55,021	21,088	1,775	642	6
(FY2014)	1,186	-37	9	15	0

Categories	Green areas along rivers and erosion control sites [ha]	Green areas around government buildings [ha]	Green areas around public rental housing [ha]	Total [ha]
FY1990	58	12	203	5,871
FY1990-FY2014	1,713	300	2,343	82,887
(FY2014)	12	4	61	1,250

11.6. Article 3.3

11.6.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2020 and are direct human-induced

Japan identifies AR and D by detecting a change of the forest cover which has occurred since 1 January 1990 using orthophotos taken at the end of 1989 and recent satellite images. In doing so, AR and forest restoration through natural succession are distinguished through imagery interpretation whether each forest cover change is human-induced or not. Whether land conversion is human-induced or not is judged by the imagery interpretation from the condition that whether any signs of human activity such as uniform tree species and uniform tree height, artificial forestation blocks, or work roads for forestation are observed or not.

11.6.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation

In Japan, land conversion from forest land to other land use means exclusion of the land from forest plans. Therefore, as far as the area of harvested forest would remain included in forest plans, the area would be considered to be subject not to D but to temporary loss of biomass stock, and in Forest Registers would be distinguished from D which means conversion to other land use.

Japan identifies forest cover change as D only in the case when land form transformation or artificial construction are observed or obvious conversion to non-forest land such as cropland are detected through imagery interpretation using aerial photos and satellite images. By this methodology, D is distinguished from temporary loss of biomass stock in forest land such as clearcut under ongoing forestry activities.

Sample field surveys are conducted at plots which are interpreted as D areas in several prefectures every year, and accuracy of D interpretation is approximately 76% on average.

The total area of forest land that has temporarily lost forest cover due to harvesting or disturbance and which are not classified as deforested but as “cut-over forests” in Forest Registers was about 95 thousand ha in 2014.

The period for tree planting after a harvest event is determined as being within two years at the latest under the standard based on the Forest Law. In the case of natural regeneration, it is expected that trees are established within five years following a harvest event.

11.7. Article 3.4

11.7.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

11.7.1.1. Forest Management

The status of FM activities since 1 January 1990 has been investigated since FY2007 by sample surveys including field surveys, interviews with forest owners’ associations and detection of administrative information on subsidies for forest practices, of ikusei-rin forests throughout the country. The results of the survey have been used to estimate the FM ratio.

With respect to Tennensei-rin forests, the measures described in detail in section 11.4.2.4.a.b) have

been applied to the Tennensei-rin forests continuously after January 1, 1990.

11.7.1.2. Cropland Management

Cropland is land which anthropogenic management practices such fertilization management is implemented and CM land is subject to direst human induced activities from January 1, 1990 onward.

11.7.1.3. Grazing Land Management

Pasture land is land which anthropogenic management practices such fertilization management is implemented and GM land is subject to direct human induced activities from January 1, 1990 onward.

11.7.1.4. Revegetation

Japan demonstrates that RV activities have occurred since 1990 and are human induced based on the following reasons.

Table 11-46 Information that demonstrates that revegetation activities have occurred since 1 January 1990 and are human induced

Urban green facilities	Information that demonstrates that Revegetation activities have occurred since 1 January 1990 and are human induced
Urban parks	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented the "Urban Parks Status Survey" and has collected data on the notification year of urban parks. In the reporting, only urban parks which have been notified since 1 January 1990 are included. Although some urban parks were established before the notification year, Japan considers that RV activities have occurred since the notification year under the "Urban Park Act". Demonstration that activities are human induced Activity data (the number of tall trees) is calculated based on the number of tall trees per land area (tree/ha) which is developed by using data on planted tall trees. Its calculation procedure ensures that Japan extracts human-induced activities.
Green areas on roads	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented the "Road Tree Planting Status Survey" every 5 years (implemented every year since 2007) and has collected data on the number of planted tall trees. Activity data after 1990 is calculated by extrapolating or interpolating these data. Demonstration that activities are human induced In the "Road Tree Planting Status Survey", only planted tall trees have been measured. Their measurement procedure ensures that Japan extracts human induced activities.
Green areas at ports	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented complete census since 2006 and has collected relevant data (year of establishment and service area) for green areas at ports which had been established since 1990. Demonstration that activities are human induced Activity data (the number of tall trees) is calculated by using parameters of urban parks which are based on human-induced activities data.
Green areas around sewage treatment facilities	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented the "Sewage treatment Facility Status Survey" since 2006 and has collected relevant data (year of establishment and greening area) for green areas around sewage treatment facilities which had been established since 1990. Demonstration that activities are human induced Activity data (the number of tall trees) is calculated based on the number of tall trees per land area (tree/ha) which is developed by using data on planted tall trees. Its calculation procedure ensures that Japan extracts human-induced activities.
Green areas by greenery promoting systems for private green space	Extraction of activities which have occurred since 1 January 1990 It is clear that all green areas by greenery promoting systems for private green space have been established since 1 January 1990 because greenery promoting systems have been implemented since 2001. Existing tall trees before 1990 in some green areas are reported when it have been notified by the local authority mayor. They are excluded from RV land area. Demonstration that activities are human induced All green areas by greenery promoting systems for private green space have been established by human-induced activities.
Green areas along rivers and erosion	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented the "Survey on carbon dioxide absorption at source in river works" since 2007 and has collected relevant data (name, location, year of establishment, planted land area

Urban green facilities	Information that demonstrates that Revegetation activities have occurred since 1 January 1990 and are human induced
control sites	[projected area] and the number of tall trees) for river works and erosion and sediment control works which had been implemented since 1990. Demonstration that activities are human induced Activity data (the number of tall trees) is calculated based on the number of tall trees per land area (tree/ha) which is developed by using data on planted tall trees. Its calculation procedure ensures that Japan extracts human-induced activities
Green areas around government buildings	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented complete census since 2007 and has collected relevant data (name, location, year of establishment, total land area and building area) for government buildings which had been established since 1990. Demonstration that activities are human induced Activity data (the number of tall trees) is calculated based on the number of tall trees per land area (tree/ha) which is developed by using data on planted tall trees. Its calculation procedure ensures that Japan extracts human-induced activities.
Green areas around public rental housing	Extraction of activities which have occurred since 1 January 1990 MLIT has implemented the "Progress survey on tree planting for public rental housing" since 2007 and has collected relevant data (name, location, year of establishment, total land area and building area) for public rental housing which had been established since 1990. Demonstration that activities are human induced Activity data (the number of tall trees) is calculated based on the number of tall trees per land area (tree/ha) which is developed by using data on planted tall trees. Its calculation procedure ensures that Japan extracts human-induced activities.

11.7.2. Information relating to cropland management, grazing land management and revegetation for the base year and the commitment period

The anthropogenic greenhouse gas emissions/removals in "Cropland management", "Grazing land management" and "Revegetation" for the base year are those from CM, GM and RV area in 1990. The anthropogenic greenhouse gas emissions/removals in "Cropland management", "Grazing land management" and "Revegetation" for the commitment period are those from CM, GM and RV area in each year. Those emissions/removals are reported within the relevant geographical location. The data and the methodologies used are provided in sections 11.4.2.5 through 11.4.2.7 and 11.5.1.1.d through 11.5.1.1.f.

11.7.3. Information that demonstrates the emissions and removals resulting from elected Article 3.4 activities are not accounted for under activities under Article 3.3 activities

11.7.3.1. Information on emissions and removals resulting from elected Article 3.4 activities are not accounted for under activities under Article 3.3 activities

11.7.3.1.a. Information on emissions and removals by FM activities are not accounted for under Article 3.3 activities

AR and D are of higher hierarchy than FM in the land classification system of Articles 3.3 and 3.4 in Japan. Emissions and removals by AR and D are estimated in the first step, then emissions and removals by FM are estimated by subtracting emissions and removals by AR and D from emissions and removals in managed forests as explained in section 11.4.2.2 (see Figure 11-1). Therefore, emissions and removals by FM could not be included in those by AR nor D.

11.7.3.1.b. Information on emissions and removals from CM activities are not accounted under Article 3.3 activities

As described in definition of CM in section 11.3.2.2 and identifying method of CM area in section 11.4.2.5, the land that does not fall under AR can be classified as CM. In addition, in the cropland, the land that fall under D was excluded from land subject to CM.

11.7.3.1.c. Information on emissions and removals from GM activities are not accounted under Article 3.3 activities

As described in definition of GM in section 11.3.2.3 and identifying method of GM area in section 11.4.2.6, land that does not fall under AR can be classified as GM. In addition, in the pasture land, the land that fall under D was excluded from land subject to GM.

11.7.3.1.d. Information on emissions and removals from RV activities are not accounted under Article 3.3 activities

RV land is defined as the land which is not included in AR land as described in the definition section 11.3.2.4. Therefore, emissions and removals from RV could not be included in those from AR theoretically.

The area of D land which would otherwise be included in RV lands is reported in the CRF Table 4(KP-I) A.2.1. Since this land is classified as D land and is not included in RV land, all emissions and removals from this land are reported under D activity as described in the explanation of methodologies of D in section 11.5.1.1.b and those of RV in section 11.5.1.1.f. Therefore, there is no double count between D and RV and emissions and removals from RV could not be included in those from D.

11.7.3.2. Information relating to the conversion of natural forests to planted forests

Since the conversion of natural forests to planted forests are accounted as practices subject FM activity if such activities occur, emissions arising from the conversion of natural forests to planted forests are all included in FM estimation.

11.7.3.3. Information on forest reference level (Consistency)

As for reporting FM, forest management reference level (FMRL) was set as zero in Japan. For estimating five carbon pools and GHG emissions and treatment of natural disturbances, methodological consistency between the FMRL and actual calculation is ensured. Regarding the reporting HWP, reference level was set newly by using the following methodology, and is reported by carrying out technical corrections.

- ***Setting of HWP reference level***

As for setting HWP reference level, values that projected in the future for sub-categories based on the historical trend until 2012 were used. As for the projection of the future, floor area of construction, production of wooden board from 2013 to 2020 were extrapolated by means of trend from 1993 to 2012; floor area of destroyed building, production of lumber and production of paper and paper board from 2013 to 2020 were extrapolated by means of trend from 2003 to 2012. As for rate of domestic logs, average values from 2003 to 2012 were applied. Exclusion of HWP resulting from D, was predicted from annual average area of deforestation area of the last five years until 2012.

11.7.3.4. Information relating forest management reference (technical correction)

In reporting carbon stock changes of HWP pool in FM, technical correction was submitted. .

11.7.3.5. Information on newly established forest will reach at least the equivalent carbon stock

Japan does not apply the provision of Carbon Equivalent Forests (in paragraphs 37-39 of Annex to Decision/CMP.7).

11.8. Other information

11.8.1. Key category analysis for Article 3.3 activities and any elected activities under Article3.4

In accordance with Chapter 4 in Volume 1 of the *2006 IPCC Guidelines*, the activity which meets the following requirements is considered as a key category.

-The associated category under the UNFCCC is identified as key. In addition, emissions/removals from the activity are greater than the smallest category that is identified as key in the UNFCCC inventory (tier 1 level assessment).

-The estimation method is changed from previous reporting.

- ***Corresponding key categories under the UNFCCC***

Japan's LULUCF key categories under the UNFCCC for 2014 (Annex 1 of this report) are as follows;

- 4.A.1. Forest land remaining forest land (CO_2)
- 4.A.2. Land converted to forest land (CO_2)
- 4.B.1. Cropland remaining cropland (CO_2)
- 4.B.2. Land converted to cropland (CO_2)
- 4.E.1. Settlements remaining settlements (CO_2)
- 4.E.2. Land converted to settlements (CO_2)
- 4.F.2. Land converted to other land (CO_2)

In accordance with *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*, AR, D, FM, CM and RV may be identified as key categories under the Kyoto Protocol.

Table 11-47 Relationship between UNFCCC categories and Kyoto Protocol activities

UNFCCC category under the Convention	Kyoto Protocol category
4.A.1. Forest land remaining forest land	FM
4.A.2. Land converted to forest land	AR
4.B.1. Cropland remaining cropland	CM
4.B.2. Land converted to cropland	D
4.C.1. Grassland remaining grassland	GM
4.C.2. Land converted to grassland	D
4.D.1. Wetlands remaining wetlands	
4.D.2. Land converted to wetlands	D
4.E.1. Settlements remaining settlements	RV
4.E.2. Land converted to settlements	D, RV
4.F.1. Other land remaining other land	―
4.F.2. Land converted to other land	D

The relationship between the Convention categories and the Kyoto categories in this table is based on the Table 2.1.1 of the *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol*, and the definitions of Articles 3.3 and 3.4 activities in Japan. Shade indicates the key categories under the UNFCCC.

- ***Comparison with the smallest key category under the UNFCCC***

The smallest category for the UNFCCC (Tier 1 level assessment) for 2014 was 1.A.1 Energy Industries (Other Fossil Fuels) (CO_2) [6,827 kt-CO_2]. As a result of the comparison, only FM activity was greater than this category.

- ***Qualitative considerations***

Since the removals by RV lands have been increasing since FY1990, RV was regarded as a key category.

Therefore, AR, D, FM, CM and RV activities (CO_2) are identified as key activities for 2014.

11.8.2. Further improvements

Methodological issues relating to Articles 3.3 and 3.4 are identified under the committee for greenhouse gas emissions estimation methods- breakout group on LULUCF. They are updated every year taking into account the progress of the inventory-related work and issues identified by the expert review team. Many of the improvement plans on LULUCF reporting under the Convention described in Chapter 6 of this report are closely linked to activities under Articles 3.3 and 3.4 of the Kyoto Protocol. Therefore, both the reporting under the Convention and the reporting under the Kyoto Protocol are discussed together. Major issues to be improved are as follows:

- Improvement of methodology and data to estimate carbon stock change in soil due to land-use conversion which reflects changes in management practices more properly is under discussion in Japan.
- With regard to the annual growth rate of living biomass per tree in RV land, Japan plans to improve the accuracy when new country-specific data by tree species become available.
- Except for urban parks and green areas at ports, carbon stock change in soils is not included in the reporting because soils are not sources of GHGs under RV activities. Japan will continue to collect fundamental information on soil carbon and consider about estimation methods.
- With respect to uncertainties on KP-LULUCF activities, Japan has shown uncertainties as disaggregated as possible in section 11.5.1.7 in chapter 11, and provided additional information in description on each category in Chapter 6. Japan will addresses how to systematically show information on uncertainties more disaggregated than those shown in the present NIR as a long-term issue.

11.9. Information relating to Article 6

Japan has not carried out any projects under Article 6 of the Kyoto Protocol. Therefore, a special indication of whether the boundary of the geographical location encompasses land subject to the Article 6 project is not prepared.

11.10. Information on the reporting status of the Annex II to decision 2/CMP.8

The requirements for reporting about Articles 3.3 and 3.4 which are set out in the annex II to decision 2/CMP.8 are provided in sections shown in Table 11-48.

Table 11-48 List of reference sections for the requirements set in the annex II to decision2/CMP.8

Checklist for KP reporting (paragraphs 1-5 in the annex to decision 2/CMP.8)		Paragraph	Main sections of Chapter 11 providing relevant information
Information on how inventory methodologies have been applied taking into account *2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol* and decision 16/CMP.1		2 (a)	Detailed information is provided in each section
Information on the geographical location of the boundaries of areas that encompass:		2 (b)	11.4.3, 11.4.2
	Units of land subject to activities under Article 3.3	2 (b) (i)	11.4.3, 11.4.2
	Units of land subject to activities under Article 3.3, which would otherwise be included in land subject to elected activities under Article 3.4	2 (b) (ii)	11.4.3, 11.4.2 and CRF table 4(KP-I)A.2.1
	Land subject to elected activities under Article 3.4	2 (b) (iii)	11.4.3, 11.4.2
Information on the spatial assessment unit for determining the area of accounting for ARD		2 (c)	11.4.1
GHG emissions by sources and removals by sinks from LULUCF activities under Articles 3.3 and 3.4:			
	Emissions by sources and removals by sinks are clearly distinguished from emissions from Annex A sources	1	11.5.1: Methodology
	Emissions by sources and removals by sinks are reported for all geographical locations reported in current and previous years	2 (d)	11.4.2.3, 11.4.2.4, 11.4.2.5, 11.4.2.6, 11.4.2.7
	Emissions/removals from Articles 3.3 or (elected) 3.4 activities are reported since the beginning of the commitment period or the onset of the activity	2 (d)	11.5.1.9
	Information on which pools (above-ground / below-ground biomass, litter, dead wood and soil organic carbon) were not accounted for	2 (e)	11.5.1.2
	Information on how emissions from natural disturbance are considered	2 (f)	11.5.1.3
	Information on GHG emissions /removals from the harvested wood products pool	2 (g)	11.5.1.4
	Information on whether Articles 3.3 and (elected) 3.4 emissions/removals factor out removals from (i) elevated CO_2 concentrations above pre-industrial levels; (ii) indirect N deposition; and (iii) dynamic effects of age structure resulting from pre-1 January 1990 activities	3	11.5.1.5
Specific information to be reported for Article 3.3 activities			
	Information that activities under Article 3.3 began on or after 1 January 1990 and before 31 December of the last year of the commitment period	4 (a)	11.6.1
	Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation	4 (b)	11.6.2
Specific information to be reported for Article 3.4 activities			
	Information that activities under Article 3.4 occurred since 1 January 1990 and are human induced.	5 (a)	11.7.1
	CM, GM, RV: emissions/removals reported for each year of the commitment period and for the base year for each of the elected activities on the geographical locations reported	5 (b)	11.7.2, 11.4.2.5, 11.4.2.6, 11.4.2.7, 11. 5.1.1.d, 11.5.1.1.e, 11.5.11.f
	Information that emissions/removals from Article 3.4 activities are not accounted for under activities under Article 3.3	5 (c)	11.7.3.1
	Information how all emissions arising from the conversion of natural forests to planted forests are accounted for	5 (d)	11.7.3.2
	Information that demonstrates methodological consistency between the reference level and reporting for FM during the second commitment period	5 (e)	11.7.3.3
	Information on technical corrections between the reference level and reporting for FM during the second commitment period	5 (f)	11.7.3.4
	Information on newly established forest will reach at least the equivalent carbon stock	5 (g)	11.7.3.5

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Chapter 12. Information on accounting of Kyoto units

In line with paragraph 10 of the annex to decision 15/CMP.1 and paragraph 14 of decision 3/CMP.11, Japan reports the information on holdings and transactions of Kyoto units (ERUs, CERs, lCERs, tCERs, AAUs and RMUs)[1]. For the reporting, in accordance with paragraph 11 of annex of decision 15/CMP.1, Japan uses Standard electronic format (SEF) defined in the annex of decision 14/CMP.1. Apart from this NIR, SEF is submitted to the UNFCCC Secretariat with the file name "RREG1_JP_CP1_2015_ver2.xlsx".

12.1. Summary of information reported in the SEF tables

For information on Kyoto units in Japan's National Registry, see the "Standard Electric Format for Reporting of Information on Kyoto Protocol Units" (RREG1_JP_CP1_2015_ver2.xlsx) submitted on the basis of Decision 14/CMP. 1, together with this NIR.

Japan also submits "RREG1_JP_CP2_2015.xlsx".

12.2. Discrepancies and notifications

Regarding Japan's national registry, discrepancies and notifications to be reported in accordance with paragraphs 12-17 of annex to decision 15/CMP.1 are as follows.

Table 12-1 Discrepancies and notifications

Reporting item	Description
Para. 12 of the annex to decision 15/CMP.1 Discrepancies	There was no discrepancy to be reported.
Para. 13 of the annex to decision 15/CMP.1 Notification from Executive Board of CDM	There was no notification regarding lCERs to be replaced due to a reversal of storage.
Para. 14 of the annex to decision 15/CMP.1 Failure of certification	There was no notification regarding lCERs to be replaced due to non-submission of certification report.
Para. 15 of the annex to decision 15/CMP.1 List of non-replacements	There was no record of non-replacement identified by the transaction log.
Para. 16 of the annex to decision 15/CMP.1 Invalid Kyoto units	There were no units that are invalid for use towards compliance with commitments.
Para. 17 of the annex to decision 15/CMP.1 Discrepant transaction that needs actions to correct problem	There was no discrepant transaction that needs actions to correct problem.

12.3. Publicly accessible information

As presented in the section IV of Part 2 of "Report on Japan's Assigned Amount", a list of the information publicly accessible by means of the user interface to the national registry is as below:

- Account information as required by paragraph 45, annex, Decision 13/CMP.1

[1] Kyoto units are: emission reduction units (ERU) from joint implementation (JI) projects, certified emission reductions (CERs) from clean development mechanism (CDM) projects, temporary certified emission reductions (tCERs) and long-term certified emission reductions (lCERs) from afforestation/reforestation CDM projects, assigned amount units (AAUs) and removal units (RMUs) from KP-LULUCF activities within Annex I Parties.

- Article 6 project information as required by paragraph 46, annex, Decision 13/CMP.1
- Kyoto units information as required by paragraph 47, annex, Decision 13/CMP.1
- Legal entities as required by paragraph 48, annex, Decision 13/CMP.1

The information is provided in “Publicly Accessible Information” of Japan’s national registry website.

- URL of the Japan’s national registry system: http://www.registry.go.jp/index_e.html
- Publicly Accessible Information: http://www.registry.go.jp/public_info_en.html

The following information is not published due to confidentiality concerns:

- Unit holdings at an individual account level
- Identity of accounts to which Japan’s national registry transferred units and those from which it acquired units.

In addition, for better readability, information on units is not associated with their respective serial numbers.

12.4. Calculation of the commitment period reserve (CPR)

Since Japan does not have a quantified emission limitation or reduction commitment for the second commitment period, it does not have a commitment period reserve.

Chapter 13. Information on changes in national system

In line with paragraph 50 (J) of the UNFCCC Inventory Reporting Guidelines, and paragraph 21 of the annex to decision 15/CMP.1, Japan reports the changes in its national system from the previous inventory submission.

- No changes have been made since the previous inventory submission.

Chapter 14. Information on changes in national registry

In line with paragraph 22 of the Annex to decision 15/CMP.1 and paragraph 14 of decision 3/CMP.11, Japan reports changes in the national registry of Japan from the previous inventory submission.

14.1. Summary of changes made on national registry of Japan in 2015

Table 14-1 Summary of changes made on national registry of Japan in 2015

Reporting Items	Descriptions of Changes
15/CMP.1, annex II, para 32. (a) Change of name or contact	No change
15/CMP.1, annex II, para 32. (b) Change of cooperation arrangement	No change
15/CMP.1, annex II, para 32. (c) Change to database or the capacity of national registry	No change
15/CMP.1, annex II, para 32. (d) Change of conformance to technical standards	No change
15/CMP.1, annex II, para 32. (e) Change of procedures to minimize discrepancies	No change
15/CMP.1, annex II, para 32. (f) Change of security measures	No change
15/CMP.1, annex II, para 32. (g) Change of a list of publicly accessible information	Information on unit holdings and transactions is made publicly available on the basis of Standard Electronic Format (SEF) to meet the requirement specified in decision 14/CMP.1. In June 2015, the information for 2014 was published. The following information is not published due to confidentiality concerns: - Unit holdings at an individual account level - Identity of accounts to which national registry of Japan transferred units and those from which it acquired units. In addition, for better readability, information on units is not associated with their respective serial numbers.
15/CMP.1, annex II, para 32. (h) Change of the internet address	No change
15/CMP.1, annex II, para 32. (i) Change of measures for ensuring data integrity	No change
15/CMP.1, annex II, para 32. (j) Change of test results	No change

14.2. Information relevant to the changes made on national registry of Japan

- In February 2015, the middleware was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In February 2015, the DNS server was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In May 2015, the DNS server was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In June 2015, public information on the unit holdings and transactions conducted was updated on the basis of the SEF for 2014, for the purpose of meeting the requirement specified in decision 13/CMP.1. The following information, which is requested to be made publicly available in

decision 13/CMP.1, has not been made so due mostly to confidentiality concerns (relevant paragraph numbers of the annex to decision 13/CMP.1 are indicated in parentheses):

- The full name of the representative of the account holder (paragraph 45(e))
- Serial numbers of ERUs, CERs, AAUs and RMUs those are subject of this public information (paragraph 47)
- The total quantity of ERUs, CERs, AAUs and RMUs in each account at the beginning of the year (the total quantity is only available by account type) (paragraph 47(a))
- The identity of the transferring accounts from which ERUs, CERs, AAUs and RMUs were acquired by national registry of Japan during the year (the identity of the transferring registries is available) (paragraph 47(d))
- The identity of the acquiring accounts to which ERUs, CERs, AAUs and RMUs were transferred from national registry of Japan during the year (the identity of the acquiring registries is available) (paragraph 47(g))
- Current holdings of ERUs, CERs, AAUs and RMUs in each account (the current holdings are only available by account type) (paragraph 47(l))

- In July 2015, the management server was changed. There is no impact on the functions of the ITL and other national registries.
- In August 2015, the DNS server was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In September 2015, the DNS server was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In December 2015, the middleware were updated. There is no impact on the functions of the ITL and other national registries.
- In December 2015, due to the end of the true-up period of the first commitment period, the following information was made publicly available for the purpose of meeting the requirement specified in decision 13/CMP.1 (relevant paragraph numbers of the annex to decision 13/CMP.1 are indicated in parentheses):
  - The serial numbers of the units in the retirement account at the end of the true-up period (paragraph 49(b))
  - The serial numbers of the units requested to be carried over from the first to the second commitment period (paragraph 49(c))

The information is provided in “Publicly Accessible Information” of Japan’s national registry website.

- URL of the Japan’s national registry system: http://www.registry.go.jp/index_e.html
- Publicly Accessible Information: http://www.registry.go.jp/public_info_en.html

Chapter 15. Information on minimization of adverse impacts in accordance with Article 3, paragraph 14

In line with paragraphs 23-25 of the Annex to decision 15/CMP.1 and paragraph 4 of Annex III to decision 1/CMP.11, Japan reports the information on minimization of adverse impacts in accordance with Article 3, paragraph 14. Changes made since the last submission are indicated with underlines.

15.1. Overview

Japan takes actions, taking into account the importance to make effort to minimize adverse impacts in accordance with Article 3, paragraph 14. On the other hand, it should be noted that we have difficulty in accurately assessing specific adverse impacts due to the implementation of response measures to address climate change issues. For example, the fluctuations in crude oil prices are caused by balance between supply and demand as well as numerous other factors (e.g., trend in crude oil futures market or economic fluctuation), and it is uncertain whether there exists a causal link or, if so, to what extent it results from adverse impacts of climate change policy and measures.

In addition, it is necessary to change the perception of response measures in order to address climate change issues effectively, and sustainable development could be the one of the key options. For instance, the introduction of renewable energy leads to improve energy access, prepare for a disaster and create employment through development of a new industry, as well as contributes to reducing GHG emissions. As discussed in Rio+20 and COP, the transition to green economy and the attainment of low-carbon growth are the key elements in order to address climate change and to achieve the sustainable development which strikes a balance between environment and economy. Efforts toward the establishment of low-carbon society should be accelerated throughout the world. Japan proposed "East Asia Low Carbon Growth Partnership" with the aim of promoting low-carbon growth through regional cooperation among the participating countries of the East Asia Summit and presented "A proposal from East Asia Low Carbon Growth Partnership Dialogue - Transformation to Low Carbon Growth –"which contains some good practices towards the low carbon economic growth at a COP21 official side event. In order to facilitate the achievement of an agreement at COP21, Japan announced its new policies of contribution called "Actions for Cool Earth 2.0 (ACE 2.0)" which consists of two pillars: (1) providing support to developing countries worth of 1.3 trillion yen in 2020 and (2) promoting innovation. Japan continues to proactively contribute to the international community in these fields.

15.2. Actions to minimize adverse impacts in accordance with Article 3, paragraph 14

Japan has given a priority to the efforts below, taking into consideration that these efforts are important to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention in implementing the commitments under Article 3, paragraph 1 of the Kyoto Protocol.

At the same time, it should be noted that it is impossible to evaluate these efforts since the method of evaluation has not been established internationally.

- ***Technical assistance in the energy and environmental sectors***

Japan has provided technical assistance in the field of energy and environment throughout the world and has contributed to the sustainable economic growth of developing countries taking into consideration their needs. For example, Japan has provided cooperation for development and operation of institutions related to energy-saving and renewable energy through capacity building such as inviting trainees from, and sending experts to developing countries including in Middle East region. Moreover, from the view point of deployment of renewable energy in small island nations particularly vulnerable to climate change, Japan, in collaboration with International Renewable Energy Agency (IRENA), invited governmental officials from Asia-Pacific and other small island nations to international workshop in Kuala Lumpur (August 2015) and training program in Tokyo (February 2016) for capacity building and support for developing projects.

- ***Development of carbon capture and storage (CCS) technologies***

Recognizing that CCS is an important technology for global warming countermeasures, Japan has been implementing large-scale demonstration projects toward practical use of CCS by around 2020, as well as researches and developments on cost reductions and safety improvements. Also, Japan actively exchanged information on CCS technologies with other countries such as the United States of America and European countries. In addition, from 2014FY, Japan has been implementing feasibility studies for an evaluation of environmental impacts in the CO_2 capture process and a shuttle ship transportation and injection system and surveys to identify potential CO_2 storage sites in waters surrounding Japan.

In terms of institutions regarding the sub-seabed geological storage of CO_2 (offshore CCS), Japan amended the Marine Pollution Prevention Law in 2007 and built up the system of permission by the Minister of the Environment with the point of view of preserving the marine environment. It examined the methods of the potential environmental impact assessment and monitoring technology. The research for sea water and ecosystem in the sea off Japan was conducted to judge the application of the sub-seabed geological storage of CO_2. The way of the long-term monitoring for the sub-seabed geological storage of CO_2 was also examined.

Annex 1. Key Categories

A1.1. Outline of Key Category Analysis

The *UNFCCC Inventory Reporting Guidelines*[1] require the application of the *2006 IPCC Guidelines*, and the key category analysis given in the Guidelines. The key category analyses were done for both data of FY2014 (the latest reported year) and of FY1990 (the base year for the UNFCCC). Their results are presented here.

A1.2. Results of Key Category Analysis

A1.2.1. Key Categories

Key categories were assessed in accordance with the *2006 IPCC Guidelines* assessment methods (Approach 1 level assessment, Approach 1 trend assessment, Approach 2 level assessment and Approach 2 trend assessment).

The key category for Land use, land use change and forestry (LULUCF) sector were identified for the inventory excluding LULUCF first, and then the key category analysis was repeated for the full inventory including the LULUCF categories.

As a result, 47 and 40 sources and sinks were detected as the key categories for FY2014 and FY1990, respectively (Table A1-1 and A1-2).

[1] Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Decision 24/CP.19)

Table A1-1 Japan's key categories (FY2014)

	A IPCC Category		B GHGs	Ap1-L	Ap1-T	Ap2-L	Ap2-T
#1	1.A.1. Energy Industries	Solid Fuels	CO2	#1	#1	#1	#2
#2	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	#2	#12	#3	#28
#3	1.A.3. Transport	b. Road Transportation	CO2	#3		#4	
#4	1.A.1. Energy Industries	Gaseous Fuels	CO2	#4	#2	#12	#14
#5	1.A.1. Energy Industries	Liquid Fuels	CO2	#5	#4	#8	#8
#6	1.A.4. Other Sectors	Liquid Fuels	CO2	#6	#5	#9	#16
#7	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	#7	#3	#13	#6
#8	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	#8	#10	#2	#7
#9	1.A.4. Other Sectors	Gaseous Fuels	CO2	#9	#8	#32	
#10	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	#10	#7		#29
#11	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	#11	#6	#7	#4
#12	2.A Mineral Product	1. Cement Production	CO2	#12	#11	#21	#20
#13	3.C Rice Cultivation		CH4	#13		#23	
#14	5.C Incineration and Open Burning of Waste		CO2	#14		#10	
#15	1.A.3. Transport	d. Domestic Navigation	CO2	#15	#21		
#16	1.A.3. Transport	a. Domestic Aviation	CO2	#16			
#17	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	#17	#17	#16	#17
#18	3.A Enteric Fermentation		CH4	#18		#11	#19
#19	1.A.1. Energy Industries	Other Fossil Fuels	CO2	#19		#24	
#20	3.B Manure Management		N2O			#5	
#21	4.B Cropland	1. Cropland remaining Cropland	CO2		#16	#15	#5
#22	3.D Agricultural Soils	1. Direct Emissions	N2O			#26	#24
#23	5.A Solid Waste Disposal		CH4		#15	#28	#10
#24	2.B Chemical Industry	Other products except Anmonia	CO2			#14	#21
#25	1.A.1. Energy Industries		N2O			#27	#22
#26	2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs			#18	#12
#27	3.B Manure Management		CH4			#34	
#28	3.D Agricultural Soils	2. Indirect Emissions	N2O			#6	#13
#29	1.A.2. Manufacturing Industries and Construction		N2O			#30	
#30	4.E Settlements	1. Settlements remaining Settlements	CO2			#31	
#31	2.E Electronics Industry		PFCs			#17	
#32	5.D Wastewater Treatment and Discharge		CH4				#27
#33	2.F Product uses as substitutes for ODS	5. Solvents	PFCs		#22		#26
#34	1.A.3. Transport	b. Road Transportation	N2O			#25	#9
#35	2.G Other Product Manufacture and Use		SF6		#13	#19	#1
#36	5.C Incineration and Open Burning of Waste		N2O			#22	
#37	4.E Settlements	2. Land converted to Settlements	CO2		#19		#15
#38	5.D Wastewater Treatment and Discharge		N2O			#29	
#39	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4		#18		#3
#40	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O			#33	#11
#41	2.E Electronics Industry		SF6			#20	
#42	4.A Forest Land	2. Land converted to Forest Land	CO2				#31
#43	4.B Cropland	2. Land converted to Cropland	CO2				#23
#44	4.F Other Land	2. Land converted to Other Land	CO2				#30
#45	2.B Chemical Industry	3. Adipic Acid Production	N2O		#14		#18
#46	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs		#9		#25
#47	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	SF6		#20		

N.B.1) Ap1-L: Approach1-Level Assessment, Ap1-T: Approach1-Trend Assessment,
Ap2-L: Approach2-Level Assessment, Ap2-T: Approach2-Trend Assessment
N.B.2) Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table A1-2 Japan's key categories (FY1990)

	A IPCC Category		B GHGs	Ap1-L	Ap2-L
#1	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	#1	#2
#2	1.A.3. Transport	b. Road Transportation	CO2	#2	#4
#3	1.A.1. Energy Industries	Liquid Fuels	CO2	#3	#6
#4	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	#4	#7
#5	1.A.4. Other Sectors	Liquid Fuels	CO2	#5	#12
#6	1.A.1. Energy Industries	Solid Fuels	CO2	#6	#11
#7	1.A.1. Energy Industries	Gaseous Fuels	CO2	#7	#27
#8	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	#8	#1
#9	2.A Mineral Product	1. Cement Production	CO2	#9	#19
#10	1.A.4. Other Sectors	Gaseous Fuels	CO2	#10	
#11	3.C Rice Cultivation		CH4	#11	#25
#12	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	#12	
#13	1.A.3. Transport	d. Domestic Navigation	CO2	#13	
#14	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	#14	
#15	5.C Incineration and Open Burning of Waste		CO2	#15	#17
#16	4.B Cropland	1. Cropland remaining Cropland	CO2	#16	#9
#17	5.A Solid Waste Disposal		CH4	#17	#15
#18	3.A Enteric Fermentation		CH4	#18	#14
#19	2.G Other Product Manufacture and Use		SF6	#19	#3
#20	2.C Metal Production	1 Iron and Steel Production	CO2	#20	
#21	2.B Chemical Industry	3. Adipic Acid Production	N2O	#21	#29
#22	1.A.3. Transport	a. Domestic Aviation	CO2	#22	
#23	1.A.1. Energy Industries	Other Fossil Fuels	CO2	#23	#26
#24	2.A Mineral Product	2. Lime Production	CO2	#24	
#25	1.A.4. Other Sectors	Solid Fuels	CO2	#25	
#26	4.E Settlements	2. Land converted to Settlements	CO2	#26	#24
#27	3.D Agricultural Soils	1. Direct Emissions	N2O	#27	#20
#28	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4		#10
#29	3.B Manure Management		N2O		#8
#30	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2		#30
#31	2.B Chemical Industry	Other products except Anmonia	CO2		#16
#32	1.A.3. Transport	b. Road Transportation	N2O		#13
#33	3.B Manure Management		CH4		#32
#34	5.D Wastewater Treatment and Discharge		CH4		#31
#35	3.D Agricultural Soils	2. Indirect Emissions	N2O		#5
#36	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O		#18
#37	2.E Electronics Industry		PFCs		#22
#38	5.C Incineration and Open Burning of Waste		N2O		#23
#39	5.D Wastewater Treatment and Discharge		N2O		#28
#40	2.E Electronics Industry		SF6		#21

N.B.1) Ap1-L: Approach1-Level Assessment, Ap2-L: Approach2-Level Assessment
N.B.2) Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

A1.2.2. Level Assessment

Level assessment involves an identification of categories as a key by calculating the proportion of emissions and removals in each category to the total emissions and removals. The calculated values of proportion are added from the category that accounts for the largest proportion, until the sum reaches 95% for Approach 1, 90% for Approach 2. Approach 1 level assessment uses emissions and removals from each category directly and Approach 2 level assessment analyzes the emissions and removals of each category, multiplied by the uncertainty of each category.

The key category analysis was first conducted for the inventory excluding LULUCF and the key categories for source sectors were identified (1). Then the key category analysis was repeated again for the full inventory including the LULUCF categories and key categories for LULUCF sector were identified (2). A source category, which was identified as key in (1) but not in (2), was still regarded as key; while a source category, which was not identified as key in (1) but was done in (2), was not

regarded as key (gray rows in tables below).

Approach 1 level assessment of the latest emissions and removals (FY2014) gives the following 19 sub-categories as the key categories (Table A1-3). Approach 2 level assessment of the latest emissions and removals (FY2014) gives the following 34 sub-categories as the key categories (Table A1-4).

Table A1-3 Results of Approach 1 level assessment (FY2014)

	A IPCC Category		B Direct GHGs	D Current Year Estimate [Gg-CO_2 eq.]	E Ap1-L	F % Ap1-L Contrib.	Cumulative
#1	1.A.1. Energy Industries	Solid Fuels	CO2	249,134.85	0.173	17.3%	17.3%
#2	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	208,401.00	0.145	14.5%	31.8%
#3	1.A.3. Transport	b. Road Transportation	CO2	186,581.66	0.130	13.0%	44.8%
#4	1.A.1. Energy Industries	Gaseous Fuels	CO2	179,244.57	0.125	12.5%	57.3%
#5	1.A.1. Energy Industries	Liquid Fuels	CO2	96,504.75	0.067	6.7%	64.0%
#6	1.A.4. Other Sectors	Liquid Fuels	CO2	84,479.85	0.059	5.9%	69.8%
#7	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	72,360.34	0.050	5.0%	74.9%
#8	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	65,043.21	0.045	4.5%	79.4%
#9	1.A.4. Other Sectors	Gaseous Fuels	CO2	47,042.05	0.033	3.3%	82.7%
#10	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	38,366.30	0.027	2.7%	85.3%
#11	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	32,555.83	0.023	2.3%	87.6%
#12	2.A Mineral Product	1. Cement Production	CO2	26,557.38	0.018	1.8%	89.4%
#13	3.C Rice Cultivation		CH4	17,903.97	0.012	1.2%	90.7%
#14	5.C Incineration and Open Burning of Waste		CO2	12,345.82	0.009	0.9%	91.5%
#15	1.A.3. Transport	d. Domestic Navigation	CO2	10,993.35	0.008	0.8%	92.3%
#16	1.A.3. Transport	a. Domestic Aviation	CO2	10,172.05	0.007	0.7%	93.0%
#17	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	9,023.84	0.006	0.6%	93.6%
#18	3.A Enteric Fermentation		CH4	7,222.58	0.005	0.5%	94.1%
#19	1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,827.12	0.005	0.5%	94.6%
#20	2.C Metal Production	1 Iron and Steel Production	CO2	6,134.71	0.004	0.4%	95.0%

Table A1-4 Results of Approach 2 level assessment (FY2014)

	A IPCC Category		B Direct GHGs	D Current Year Estimate [Gg-CO2 eq.]	I Source/Sink Uncertainty	K % Ap2-L Contrib.	Cumulative
#1	1.A.1. Energy Industries	Solid Fuels	CO2	249,134.85	3%	10.8%	10.8%
#2	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	65,043.21	12%	10.8%	21.6%
#3	1.A.2. Manufacturing Industries and	Solid Fuels	CO2	208,401.00	3%	9.1%	30.7%
#4	1.A.3. Transport	b. Road Transportation	CO2	186,581.66	2%	5.6%	36.3%
#5	3.B Manure Management		N2O	4,493.78	82%	4.9%	41.2%
#6	3.D Agricultural Soils	2. Indirect Emissions	N2O	1,949.56	164%	4.2%	45.4%
#7	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	32,555.83	7%	3.0%	48.4%
#8	1.A.1. Energy Industries	Liquid Fuels	CO2	96,504.75	2%	2.9%	51.3%
#9	1.A.4. Other Sectors	Liquid Fuels	CO2	84,479.85	2%	2.5%	53.8%
#10	5.C Incineration and Open Burning of Waste		CO2	12,345.82	15%	2.5%	56.3%
#11	3.A Enteric Fermentation		CH4	7,222.58	25%	2.4%	58.8%
#12	1.A.1. Energy Industries	Gaseous Fuels	CO2	179,244.57	1%	2.4%	61.2%
#13	1.A.2. Manufacturing Industries and	Liquid Fuels	CO2	72,360.34	2%	2.2%	63.4%
#14	2.B Chemical Industry	Other products except Anmonia	CO2	2,791.37	55%	2.0%	65.4%
#15	4.B Cropland	1. Cropland remaining Cropland	CO2	4,291.23	33%	1.9%	67.3%
#16	1.A.2. Manufacturing Industries and	Other Fossil Fuels	CO2	9,023.84	15%	1.9%	69.1%
#17	2.E Electronics Industry		PFCs	1,706.59	81%	1.8%	71.0%
#18	2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	2,372.95	50%	1.6%	72.5%
#19	2.G Other Product Manufacture and Use		SF6	1,454.63	76%	1.5%	74.0%
#20	2.E Electronics Industry		SF6	365.83	300%	1.5%	75.5%
#21	2.A Mineral Product	1. Cement Production	CO2	26,557.38	4%	1.5%	76.9%
#22	5.C Incineration and Open Burning of Waste		N2O	1,435.89	76%	1.4%	78.4%
#23	3.C Rice Cultivation		CH4	17,903.97	6%	1.4%	79.8%
#24	1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,827.12	15%	1.4%	81.2%
#25	1.A.3. Transport	b. Road Transportation	N2O	1,471.35	72%	1.4%	82.6%
#26	3.D Agricultural Soils	1. Direct Emissions	N2O	3,769.97	27%	1.3%	83.9%
#27	1.A.1. Energy Industries		N2O	2,550.38	36%	1.2%	85.2%
#28	5.A Solid Waste Disposal		CH4	3,313.71	23%	1.0%	86.2%
#29	5.D Wastewater Treatment and Discharge		N2O	1,123.89	59%	0.9%	87.1%
#30	1.A.2. Manufacturing Industries and		N2O	1,804.17	36%	0.9%	87.9%
#31	4.E Settlements	1. Settlements remaining Settlements	CO2	1,773.47	34%	0.8%	88.7%
#32	1.A.4. Other Sectors	Gaseous Fuels	CO2	47,042.05	1%	0.6%	89.4%
#33	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O	473.66	99%	0.6%	90.0%
#34	3.B Manure Management		CH4	2,360.70	17%	0.5%	90.5%

Approach1 level assessment of the latest emissions and removals (FY1990) gives the following 27 sub-categories as the key categories (Table A1-5). Approach2 level assessment of the latest emissions and removals (FY1990) gives the following 32 sub-categories as the key categories (Table A1-6).

Table A1-5 Results of Approach 1 level assessment (FY1990)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO2eq.]	E Ap1-L	F % Ap1-L Contrib.	Cumulative
#1	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	207,261.86	0.151	15.1%	15.1%
#2	1.A.3. Transport	b. Road Transportation	CO2	178,442.29	0.130	13.0%	28.1%
#3	1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	0.127	12.7%	40.8%
#4	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	155,177.06	0.113	11.3%	52.1%
#5	1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	0.084	8.4%	60.5%
#6	1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	0.068	6.8%	67.3%
#7	1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	0.058	5.8%	73.0%
#8	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	0.056	5.6%	78.6%
#9	2.A Mineral Product	1. Cement Production	CO2	38,701.10	0.028	2.8%	81.5%
#10	1.A.4. Other Sectors	Gaseous Fuels	CO2	23,892.27	0.017	1.7%	83.2%
#11	3.C Rice Cultivation		CH4	17,294.01	0.013	1.3%	84.5%
#12	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	15,930.24	0.012	1.2%	85.6%
#13	1.A.3. Transport	d. Domestic Navigation	CO2	13,674.88	0.010	1.0%	86.6%
#14	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	13,502.24	0.010	1.0%	87.6%
#15	5.C Incineration and Open Burning of Waste		CO2	12,424.36	0.009	0.9%	88.5%
#16	4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	0.007	0.7%	89.3%
#17	5.A Solid Waste Disposal		CH4	9,220.70	0.007	0.7%	89.9%
#18	3.A Enteric Fermentation		CH4	9,064.25	0.007	0.7%	90.6%
#19	2.G Other Product Manufacture and Use		SF6	8,814.04	0.006	0.6%	91.2%
#20	2.C Metal Production	1 Iron and Steel Production	CO2	7,272.76	0.005	0.5%	91.8%
#21	2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	0.005	0.5%	92.3%
#22	1.A.3. Transport	a. Domestic Aviation	CO2	7,162.41	0.005	0.5%	92.8%
#23	1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,678.58	0.005	0.5%	93.3%
#24	2.A Mineral Product	2. Lime Production	CO2	6,674.45	0.005	0.5%	93.8%
#25	1.A.4. Other Sectors	Solid Fuels	CO2	5,721.10	0.004	0.4%	94.2%
#26	4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	0.004	0.4%	94.6%
#27	3.D Agricultural Soils	1. Direct Emissions	N2O	4,789.26	0.003	0.3%	94.9%
#28	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	0.003	0.3%	95.3%

Table A1-6 Results of Approach 2 level assessment (FY1990)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-	I Source/Sink Uncertainty	K % Ap2-L Contrib.	Cumulative
#1	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	12%	10.7%	10.7%
#2	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	207,261.86	3%	7.6%	18.3%
#3	2.G Other Product Manufacture and Use		SF6	8,814.04	76%	7.4%	25.8%
#4	1.A.3. Transport	b. Road Transportation	CO2	178,442.29	2%	4.5%	30.3%
#5	3.D Agricultural Soils	2. Indirect Emissions	N2O	2,472.78	164%	4.5%	34.8%
#6	1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	2%	4.4%	39.2%
#7	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	155,177.06	2%	3.9%	43.1%
#8	3.B Manure Management		N2O	4,249.17	82%	3.9%	47.0%
#9	4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	33%	3.8%	50.7%
#10	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	66%	3.5%	54.3%
#11	1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	3%	3.4%	57.7%
#12	1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	2%	2.9%	60.6%
#13	1.A.3. Transport	b. Road Transportation	N2O	3,457.24	72%	2.8%	63.4%
#14	3.A Enteric Fermentation		CH4	9,064.25	25%	2.6%	65.9%
#15	5.A Solid Waste Disposal		CH4	9,220.70	23%	2.4%	68.3%
#16	2.B Chemical Industry	Other products except Anmonia	CO2	3,620.20	55%	2.2%	70.6%
#17	5.C Incineration and Open Burning of Waste		CO2	12,424.36	15%	2.1%	72.7%
#18	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid Production	N2O	1,672.86	99%	1.8%	74.5%
#19	2.A Mineral Product	1. Cement Production	CO2	38,701.10	4%	1.8%	76.3%
#20	3.D Agricultural Soils	1. Direct Emissions	N2O	4,789.26	27%	1.4%	77.7%
#21	2.E Electronics Industry		SF6	418.70	300%	1.4%	79.1%
#22	2.E Electronics Industry		PFCs	1,454.78	81%	1.3%	80.4%
#23	5.C Incineration and Open Burning of Waste		N2O	1,435.25	76%	1.2%	81.6%
#24	4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	21%	1.2%	82.8%
#25	3.C Rice Cultivation		CH4	17,294.01	6%	1.2%	84.0%
#26	1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,678.58	15%	1.2%	85.2%
#27	1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	1%	0.9%	86.1%
#28	5.D Wastewater Treatment and Discharge		N2O	1,206.92	59%	0.8%	86.9%
#29	2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	9%	0.7%	87.6%
#30	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	4,170.07	15%	0.7%	88.3%
#31	5.D Wastewater Treatment and Discharge		CH4	2,859.83	22%	0.7%	89.0%
#32	3.B Manure Management		CH4	3,353.17	17%	0.6%	89.7%
#33	2.B Chemical Industry	2. Nitric Acid Production	N2O	736.06	73%	0.6%	90.3%

A1.2.3. Trend Assessment

The difference between the rate of change in emissions and removals in a category and the rate of change in total emissions and removals is calculated. The trend assessment is calculated by multiplying this value by the ratio of contribution of the relevant category to total emissions and removals. The calculated results, regarded as trend assessment values, are added from the category whose proportion to the total of trend assessment values is the largest, until the total reaches 95% for Approach 1, 90% for Approach 2. At this point, these categories are defined as the key categories. Approach1 level assessment uses emissions and removals from each category directly and Approach 2 level assessment analyzes the emissions and removals of each category, multiplied by the uncertainty of each category.

The key category analysis was first conducted for the inventory excluding LULUCF and the key categories for source sectors were identified (1). Then the key category analysis was repeated again for the full inventory including the LULUCF categories and key categories for LULUCF sector were identified (2). A source category, which was identified as key in (1) but not in (2), was still regarded as key; while a source category, which was not identified as key in (1) but was done in (2), was not regarded as key (gray rows in tables below).

Approach 1 trend assessment of the latest emissions and removals (FY2014) gives the following 22 sub-categories as the key categories (Table A1-7). Approach 2 trend assessment of the latest emissions and removals (FY2014) gives the following 31 sub-categories as the key categories (Table A1-8).

Table A1-7 Results of Approach 1 trend assessment (FY2014)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg CO2eq.]	D Current Year Estimate [Gg CO2eq.]	G Ap1-T	H % Ap1-T Contrib.	Cumulative
#1	1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	249,134.85	0.1007	22.2%	22.2%
#2	1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	179,244.57	0.0639	14.1%	36.3%
#3	1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	155,177.06	72,360.34	0.0599	13.2%	49.5%
#4	1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	96,504.75	0.0569	12.6%	62.1%
#5	1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	84,479.85	0.0242	5.3%	67.4%
#6	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	0.00	32,555.83	0.0216	4.8%	72.2%
#7	1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	13,502.24	38,366.30	0.0161	3.5%	75.7%
#8	1.A.4. Other Sectors	Gaseous Fuels	CO2	23,892.27	47,042.05	0.0146	3.2%	78.9%
#9	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	15,930.24	124.25	0.0110	2.4%	81.4%
#10	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	65,043.21	0.0104	2.3%	83.7%
#11	2.A Mineral Product	1. Cement Production	CO2	38,701.10	26,557.38	0.0093	2.0%	85.7%
#12	1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	207,261.86	208,401.00	0.0058	1.3%	87.0%
#13	2.G Other Product Manufacture and Use		SF6	8,814.04	1,454.63	0.0052	1.1%	88.1%
#14	2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	142.64	0.0049	1.1%	89.2%
#15	5.A Solid Waste Disposal		CH4	9,220.70	3,313.71	0.0042	0.9%	90.1%
#16	4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	4,291.23	0.0042	0.9%	91.1%
#17	1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	4,170.07	9,023.84	0.0031	0.7%	91.7%
#18	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	539.28	0.0030	0.7%	92.4%
#19	4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	1,419.47	0.0027	0.6%	93.0%
#20	2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	SF6	3,470.78	61.56	0.0024	0.5%	93.5%
#21	1.A.3. Transport	d. Domestic Navigation	CO2	13,674.88	10,993.35	0.0022	0.5%	94.0%
#22	2.F Product uses as substitutes for ODS	5. Solvents	PFCs	4,549.94	1,536.55	0.0021	0.5%	94.5%
#23	1.A.3. Transport	a. Domestic Aviation	CO2	7,162.41	10,172.05	0.0018	0.4%	94.9%
#24	2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	1.34	2,372.95	0.0016	0.3%	95.2%

Table A1-8 Results of Approach 2 trend assessment (FY2014)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg CO2eq.]	D Current Year Estimate [Gg-CO2 eq.]	I Source/Sink Uncertainty	L Ap2-T	M % Ap2-T Contrib.	Cumulative
#1	2.G Other Product Manufacture and Use		SF6	8,814.04	1,454.63	76%	3.91	13.5%	13.5%
#2	1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	249,134.85	3%	3.30	11.4%	24.9%
#3	1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	539.28	66%	1.96	6.8%	31.7%
#4	2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	0.00	32,555.83	7%	1.50	5.2%	36.9%
#5	4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	4,291.23	33%	1.39	4.8%	41.7%
#6	1.A.2. Manufacturing Industries and	Liquid Fuels	CO2	155,177.06	72,360.34	2%	1.36	4.7%	46.4%
#7	4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	65,043.21	12%	1.30	4.5%	50.8%
#8	1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	96,504.75	2%	1.29	4.5%	55.3%
#9	1.A.3. Transport	b. Road Transportation	N2O	3,457.24	1,471.35	72%	1.02	3.5%	58.8%
#10	5.A Solid Waste Disposal		CH4	9,220.70	3,313.71	23%	0.98	3.4%	62.2%
#11	2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid	N2O	1,672.86	473.66	99%	0.84	2.9%	65.1%
#12	2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	1.34	2,372.95	50%	0.79	2.7%	67.8%
#13	3.D Agricultural Soils	2. Indirect Emissions	N2O	2,472.78	1,949.56	164%	0.70	2.4%	70.3%
#14	1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	179,244.57	1%	0.65	2.3%	72.5%
#15	4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	1,419.47	21%	0.56	1.9%	74.4%
#16	1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	84,479.85	2%	0.55	1.9%	76.3%
#17	1.A.2. Manufacturing Industries and	Other Fossil Fuels	CO2	4,170.07	9,023.84	15%	0.48	1.7%	78.0%
#18	2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	142.64	9%	0.45	1.6%	79.5%
#19	3.A Enteric Fermentation		CH4	9,064.25	7,222.58	25%	0.38	1.3%	80.9%
#20	2.A Mineral Product	1. Cement Production	CO2	38,701.10	26,557.38	4%	0.38	1.3%	82.2%
#21	2.B Chemical Industry	Other products except Anmonia	CO2	3,620.20	2,791.37	55%	0.37	1.3%	83.4%
#22	1.A.1. Energy Industries		N2O	1,197.14	2,550.38	36%	0.31	1.1%	84.5%
#23	4.B Cropland	2. Land converted to Cropland	CO2	1,972.65	205.09	18%	0.23	0.8%	85.3%
#24	3.D Agricultural Soils	1. Direct Emissions	N2O	4,789.26	3,769.97	27%	0.22	0.8%	86.1%
#25	2.B Chemical Industry	9. Fluorochemical Production (Fugitive	HFCs	15,930.24	124.25	2%	0.22	0.8%	86.8%
#26	2.F Product uses as substitutes for ODS	5. Solvents	PFCs	4,549.94	1,536.55	10%	0.21	0.7%	87.6%
#27	5.D Wastewater Treatment and Discharge		CH4	2,859.83	1,686.58	22%	0.19	0.7%	88.2%
#28	1.A.2. Manufacturing Industries and	Solid Fuels	CO2	207,261.86	208,401.00	3%	0.19	0.7%	88.9%
#29	1.A.2. Manufacturing Industries and	Gaseous Fuels	CO2	13,502.24	38,366.30	1%	0.16	0.6%	89.5%
#30	4.F Other Land	2. Land converted to Other Land	CO2	1,454.57	165.82	17%	0.16	0.5%	90.0%
#31	4.A Forest Land	2. Land converted to Forest Land	CO2	2,076.62	338.40	12%	0.15	0.5%	90.5%

Data utilized for the key category analysis are shown in Table A1-9 and A1-10 as references.

Table A1-9 Data used for the key category analysis (FY2014)

A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg CO2eq.]	D Current Year Estimate [Gg-CO2 eq.]	E Ap1-L	F % Ap1-L Contrib.	G Ap1-T	H % Ap1-T Contrib.	I Source/Sink Uncertainty	J Ap2-L	K % Ap2-L Contrib.	L Ap2-T	M % Ap2-T Contrib.
1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	96,504.75	0.067	6.7%	0.0569	12.6%	2%	1.52	2.9%	1.29	4.5%
1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	249,134.85	0.173	17.3%	0.1007	22.2%	3%	5.67	10.8%	3.30	11.4%
1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	179,244.57	0.125	12.5%	0.0639	14.1%	1%	1.27	2.4%	0.65	2.3%
1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,678.58	6,827.12	0.005	0.5%	0.0001	0.0%	15%	0.73	1.4%	0.02	0.1%
1.A.1. Energy Industries		CH4	431.46	299.28	0.000	0.0%	0.0001	0.0%	44%	0.09	0.2%	0.04	0.2%
1.A.1. Energy Industries		N2O	1,197.14	2,550.38	0.002	0.2%	0.0009	0.2%	36%	0.64	1.2%	0.31	1.1%
1.A.2. Manufacturing Industries and Construction	Liquid Fuels	CO2	155,177.06	72,360.34	0.050	5.0%	0.0599	13.2%	2%	1.14	2.2%	1.36	4.7%
1.A.2. Manufacturing Industries and Construction	Solid Fuels	CO2	207,261.86	208,401.00	0.145	14.5%	0.0058	1.3%	3%	4.75	9.1%	0.19	0.7%
1.A.2. Manufacturing Industries and Construction	Gaseous Fuels	CO2	13,502.24	38,366.30	0.027	2.7%	0.0161	3.5%	1%	0.27	0.5%	0.16	0.6%
1.A.2. Manufacturing Industries and Construction	Other Fossil Fuels	CO2	4,170.07	9,023.84	0.006	0.6%	0.0031	0.7%	15%	0.97	1.9%	0.48	1.7%
1.A.2. Manufacturing Industries and Construction		CH4	441.22	519.27	0.000	0.0%	0.0000	0.0%	44%	0.16	0.3%	0.02	0.1%
1.A.2. Manufacturing Industries and Construction		N2O	1,384.24	1,804.17	0.001	0.1%	0.0002	0.1%	36%	0.45	0.9%	0.08	0.3%
1.A.3. Transport	a. Domestic Aviation	CO2	7,162.41	10,172.05	0.007	0.7%	0.0018	0.4%	2%	0.16	0.3%	0.04	0.1%
1.A.3. Transport	a. Domestic Aviation	CH4	5.64	1.72	0.000	0.0%	0.0000	0.0%	79%	0.00	0.0%	0.00	0.0%
1.A.3. Transport	a. Domestic Aviation	N2O	64.02	90.05	0.000	0.0%	0.0000	0.0%	110%	0.07	0.1%	0.02	0.1%
1.A.3. Transport	b. Road Transportation	CO2	178,442.29	186,581.66	0.130	13.0%	0.0003	0.1%	2%	2.94	5.6%	0.01	0.0%
1.A.3. Transport	b. Road Transportation	CH4	252.59	127.28	0.000	0.0%	0.0001	0.0%	70%	0.06	0.1%	0.06	0.2%
1.A.3. Transport	b. Road Transportation	N2O	3,457.24	1,471.35	0.001	0.1%	0.0014	0.3%	72%	0.73	1.4%	1.02	3.5%
1.A.3. Transport	c. Railways	CO2	935.40	539.63	0.000	0.0%	0.0003	0.1%	2%	0.01	0.0%	0.01	0.0%
1.A.3. Transport	c. Railways	CH4	1.34	0.76	0.000	0.0%	0.0000	0.0%	105%	0.00	0.0%	0.00	0.0%
1.A.3. Transport	c. Railways	N2O	109.95	62.36	0.000	0.0%	0.0000	0.0%	125%	0.05	0.1%	0.04	0.2%
1.A.3. Transport	d. Domestic Navigation	CO2	13,674.88	10,993.35	0.008	0.8%	0.0022	0.5%	2%	0.17	0.3%	0.05	0.2%
1.A.3. Transport	d. Domestic Navigation	CH4	31.73	24.44	0.000	0.0%	0.0000	0.0%	52%	0.01	0.0%	0.00	0.0%
1.A.3. Transport	d. Domestic Navigation	N2O	108.07	83.24	0.000	0.0%	0.0000	0.0%	91%	0.05	0.1%	0.02	0.1%
1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	84,479.85	0.059	5.9%	0.0242	5.3%	2%	1.33	2.5%	0.55	1.9%
1.A.4. Other Sectors	Solid Fuels	CO2	5,721.10	5,736.20	0.004	0.4%	0.0002	0.0%	3%	0.13	0.2%	0.01	0.0%
1.A.4. Other Sectors	Gaseous Fuels	CO2	23,892.27	47,042.05	0.033	3.3%	0.0146	3.2%	1%	0.33	0.6%	0.15	0.5%
1.A.4. Other Sectors	Other Fossil Fuels	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	15%	0.00	0.0%	0.00	0.0%
1.A.4. Other Sectors		CH4	255.03	734.55	0.001	0.1%	0.0003	0.1%	44%	0.22	0.4%	0.14	0.5%
1.A.4. Other Sectors		N2O	249.16	288.77	0.000	0.0%	0.0000	0.0%	36%	0.07	0.1%	0.01	0.0%
1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CO2	5.32	0.49	0.000	0.0%	0.0000	0.0%	71%	0.00	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	539.28	0.000	0.0%	0.0030	0.7%	66%	0.25	0.5%	1.96	6.8%
1.B Fugitive Emission from Fuel	2.a. Oil	CO2	0.03	0.03	0.000	0.0%	0.0000	0.0%	89%	0.00	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	2.a. Oil	CH4	25.36	22.17	0.000	0.0%	0.0000	0.0%	69%	0.01	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CO2	0.63	0.86	0.000	0.0%	0.0000	0.0%	80%	0.00	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CH4	174.24	229.68	0.000	0.0%	0.0000	0.0%	73%	0.12	0.2%	0.02	0.1%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CO2	81.17	209.81	0.000	0.0%	0.0001	0.0%	14%	0.02	0.0%	0.01	0.0%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CH4	7.96	5.03	0.000	0.0%	0.0000	0.0%	49%	0.00	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	N2O	0.11	0.09	0.000	0.0%	0.0000	0.0%	32%	0.00	0.0%	0.00	0.0%
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CO2	104.42	215.11	0.000	0.0%	0.0001	0.0%	17%	0.02	0.0%	0.01	0.0%
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CH4	5.21	10.52	0.000	0.0%	0.0000	0.0%	17%	0.00	0.0%	0.00	0.0%
2.A Mineral Product	1. Cement Production	CO2	38,701.10	26,557.38	0.018	1.8%	0.0093	2.0%	4%	0.76	1.5%	0.38	1.3%
2.A Mineral Product	2. Lime Production	CO2	6,674.45	5,922.18	0.004	0.4%	0.0007	0.2%	4%	0.15	0.3%	0.03	0.1%
2.A Mineral Product	3. Glass Production	CO2	153.24	93.27	0.000	0.0%	0.0000	0.0%	6%	0.00	0.0%	0.00	0.0%
2.A Mineral Product	4. Other Process Uses of Carbonates	CO2	3,689.87	2,350.79	0.002	0.2%	0.0010	0.2%	6%	0.10	0.2%	0.06	0.2%
2.B Chemical Industry	1. Ammonia Production	CO2	3,415.96	1,891.37	0.001	0.1%	0.0011	0.2%	1%	0.02	0.0%	0.02	0.1%
2.B Chemical Industry	Other products except Anmonia	CO2	3,620.20	2,791.37	0.002	0.2%	0.0007	0.1%	55%	1.07	2.0%	0.37	1.3%
2.B Chemical Industry	2. Nitric Acid Production	N2O	736.06	461.25	0.000	0.0%	0.0002	0.0%	73%	0.24	0.4%	0.15	0.5%
2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	142.64	0.000	0.0%	0.0049	1.1%	9%	0.01	0.0%	0.45	1.6%
2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid	N2O	1,672.86	473.66	0.000	0.0%	0.0008	0.2%	99%	0.32	0.6%	0.84	2.9%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	15,930.24	124.25	0.000	0.0%	0.0110	2.4%	2%	0.00	0.0%	0.22	0.8%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	PFCs	330.92	107.37	0.000	0.0%	0.0002	0.0%	2%	0.00	0.0%	0.00	0.0%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	SF6	3,470.78	61.56	0.000	0.0%	0.0024	0.5%	2%	0.00	0.0%	0.05	0.2%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	NF3	3.07	672.52	0.000	0.0%	0.0004	0.1%	2%	0.01	0.0%	0.01	0.0%
2.B Chemical Industry	whole of Chemical Industries	CH4	37.49	25.22	0.000	0.0%	0.0000	0.0%	55%	0.01	0.0%	0.01	0.0%
2.C Metal Production	1. Iron and Steel Production	CO2	7,272.76	6,134.71	0.004	0.4%	0.0010	0.2%	4%	0.16	0.3%	0.04	0.1%
2.C Metal Production	1. Iron and Steel Production	CH4	18.42	14.77	0.000	0.0%	0.0000	0.0%	163%	0.02	0.0%	0.00	0.0%
2.C Metal Production	2. Ferroalloys Production	CH4	4.63	2.91	0.000	0.0%	0.0000	0.0%	163%	0.00	0.0%	0.00	0.0%
2.C Metal Production	3. Aluminium Production	PFCs	203.66	1.91	0.000	0.0%	0.0001	0.0%	44%	0.00	0.0%	0.06	0.2%
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium	HFCs	0.00	1.29	0.000	0.0%	0.0000	0.0%	5%	0.00	0.0%	0.00	0.0%
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium	SF6	146.54	182.40	0.000	0.0%	0.0000	0.0%	5%	0.01	0.0%	0.00	0.0%
2.D Non-energy Products from Fuels and Solvent Use		CO2	392.21	294.97	0.000	0.0%	0.0001	0.0%	39%	0.08	0.2%	0.03	0.1%
2.E Electronics Industry		HFCs	0.73	115.15	0.000	0.0%	0.0001	0.0%	100%	0.08	0.2%	0.08	0.3%
2.E Electronics Industry		PFCs	1,454.78	1,706.59	0.001	0.1%	0.0001	0.0%	81%	0.96	1.8%	0.10	0.3%
2.E Electronics Industry		SF6	418.70	365.83	0.000	0.0%	0.0000	0.0%	300%	0.76	1.5%	0.15	0.5%
2.E Electronics Industry		NF3	29.82	158.20	0.000	0.0%	0.0001	0.0%	71%	0.08	0.1%	0.06	0.2%
2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	0.00	32,555.83	0.023	2.3%	0.0216	4.8%	7%	1.57	3.0%	1.50	5.2%
2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	1.34	2,372.95	0.002	0.2%	0.0016	0.3%	50%	0.83	1.6%	0.79	2.7%
2.F Product uses as substitutes for ODS	3. Fire Extinguishers	HFCs	0.00	9.06	0.000	0.0%	0.0000	0.0%	16%	0.00	0.0%	0.00	0.0%
2.F Product uses as substitutes for ODS	4. Aerosols	HFCs	0.00	503.42	0.000	0.0%	0.0003	0.1%	10%	0.04	0.1%	0.03	0.1%
2.F Product uses as substitutes for ODS	5. Solvents	HFCs	0.00	103.00	0.000	0.0%	0.0001	0.0%	32%	0.02	0.0%	0.02	0.1%
2.F Product uses as substitutes for ODS	5. Solvents	PFCs	4,549.94	1,536.55	0.001	0.1%	0.0021	0.5%	10%	0.11	0.2%	0.21	0.7%
2.G Other Product Manufacture and Use		N2O	290.86	371.22	0.000	0.0%	0.0000	0.0%	4%	0.01	0.0%	0.00	0.0%
2.G Other Product Manufacture and Use		PFCs	0.00	9.00	0.000	0.0%	0.0000	0.0%	10%	0.00	0.0%	0.00	0.0%
2.G Other Product Manufacture and Use		SF6	8,814.04	1,454.63	0.001	0.1%	0.0052	1.1%	76%	0.77	1.5%	3.91	13.5%
2.H Other	Use of Dry Ice	CO2	64.27	80.44	0.000	0.0%	0.0000	0.0%	5%	0.00	0.0%	0.00	0.0%
3.A Enteric Fermentation		CH4	9,064.25	7,222.58	0.005	0.5%	0.0015	0.3%	25%	1.28	2.4%	0.38	1.3%
3.B Manure Management		CH4	3,353.17	2,360.70	0.002	0.2%	0.0008	0.2%	17%	0.28	0.5%	0.13	0.5%
3.B Manure Management		N2O	4,249.17	4,493.78	0.003	0.3%	0.0000	0.0%	82%	2.56	4.9%	0.02	0.1%
3.C Rice Cultivation		CH4	17,294.01	17,903.97	0.012	1.2%	0.0001	0.0%	6%	0.76	1.4%	0.01	0.0%
3.D Agricultural Soils	1. Direct Emissions	N2O	4,789.26	3,769.97	0.003	0.3%	0.0008	0.2%	27%	0.70	1.3%	0.22	0.8%
3.D Agricultural Soils	2. Indirect Emissions	N2O	2,472.78	1,949.56	0.001	0.1%	0.0004	0.1%	164%	2.22	4.2%	0.70	2.4%
3.F Field Burning of Agricultural Residues		CH4	127.03	71.73	0.000	0.0%	0.0000	0.0%	296%	0.15	0.3%	0.12	0.4%
3.F Field Burning of Agricultural Residues		N2O	39.26	22.17	0.000	0.0%	0.0000	0.0%	300%	0.05	0.1%	0.04	0.1%
3.G Liming		CO2	550.24	379.58	0.000	0.0%	0.0001	0.0%	50%	0.13	0.3%	0.07	0.2%
3.H Urea Application		CO2	58.64	198.19	0.000	0.0%	0.0001	0.0%	50%	0.07	0.1%	0.05	0.2%

Table A1-9 Data used for the key category analysis (FY2014) (Continue)

A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg CO2eq.]	D Current Year Estimate [Gg-CO2 eq.]	E Ap1-L	F % Ap1-L Contrib.	G Ap1-T	H % Ap1-T Contrib.	I Source/Sink Uncertainty	J Ap2-L	K % Ap2-L Contrib.	L Ap2-T	M % Ap2-T Contrib.
4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	65,043.21	0.045	4.5%	0.0104	2.3%	12%	5.65	10.8%	1.30	4.5%
4.A Forest Land	2. Land converted to Forest Land	CO2	2,076.62	338.40	0.000	0.0%	0.0012	0.3%	12%	0.03	0.1%	0.15	0.5%
4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	4,291.23	0.003	0.3%	0.0042	0.9%	33%	0.99	1.9%	1.39	4.8%
4.B Cropland	2. Land converted to Cropland	CO2	1,972.65	205.09	0.000	0.0%	0.0012	0.3%	18%	0.03	0.0%	0.23	0.8%
4.C Grassland	1. Grassland remaining Grassland	CO2	891.81	84.93	0.000	0.0%	0.0006	0.1%	9%	0.01	0.0%	0.05	0.2%
4.C Grassland	2. Land converted to Grassland	CO2	218.86	16.57	0.000	0.0%	0.0001	0.0%	18%	0.00	0.0%	0.03	0.1%
4.D Wetlands	1.1 Peat Extraction Remaining Peat	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	21%	0.00	0.0%	0.00	0.0%
4.D Wetlands	1.2 Flooded Land Remaining Flooded Land	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	21%	0.00	0.0%	0.00	0.0%
4.D Wetlands	1.3 Other Wetlands Remaining Other	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	21%	0.00	0.0%	0.00	0.0%
4.D Wetlands	2. Land converted to Wetlands	CO2	84.65	40.99	0.000	0.0%	0.0000	0.0%	21%	0.01	0.0%	0.01	0.0%
4.E Settlements	1. Settlements remaining Settlements	CO2	1,378.73	1,773.47	0.001	0.1%	0.0002	0.0%	34%	0.42	0.8%	0.07	0.3%
4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	1,419.47	0.001	0.1%	0.0027	0.6%	21%	0.20	0.4%	0.56	1.9%
4.F Other Land	1. Other Land remaining Other Land	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	17%	0.00	0.0%	0.00	0.0%
4.F Other Land	2. Land converted to Other Land	CO2	1,454.57	165.82	0.000	0.0%	0.0009	0.2%	17%	0.02	0.0%	0.16	0.5%
4.G Harvested Wood Products		CO2	856.72	621.42	0.000	0.0%	0.0002	0.0%	30%	0.13	0.2%	0.06	0.2%
4(I). Direct N2O emissions from N inputs to managed		N2O	0.84	0.56	0.000	0.0%	0.0000	0.0%	31%	0.00	0.0%	0.00	0.0%
4(II).Drainage and rewetting		CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.0%	0.00	0.0%
4(II).Drainage and rewetting		CH4	38.75	36.99	0.000	0.0%	0.0000	0.0%	115%	0.03	0.1%	0.00	0.0%
4(II).Drainage and rewetting		N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.0%	0.00	0.0%
4(III).Direct N2O emissions from N		N2O	189.11	143.28	0.000	0.0%	0.0000	0.0%	138%	0.14	0.3%	0.05	0.2%
4(IV) Indirect N2O Emissions from Managed Soils		N2O	40.61	31.72	0.000	0.0%	0.0000	0.0%	318%	0.07	0.1%	0.02	0.1%
4(V) Biomass Burning		CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.0%	0.00	0.0%
4(V) Biomass Burning		CH4	34.22	39.31	0.000	0.0%	0.0000	0.0%	28%	0.01	0.0%	0.00	0.0%
4(V) Biomass Burning		N2O	8.30	6.97	0.000	0.0%	0.0000	0.0%	296%	0.01	0.0%	0.00	0.0%
5.A Solid Waste Disposal		CH4	9,220.70	3,313.71	0.002	0.2%	0.0042	0.9%	23%	0.54	1.0%	0.98	3.4%
5.B Biological Treatment of Soild Waste		CH4	194.63	354.99	0.000	0.0%	0.0001	0.0%	104%	0.26	0.5%	0.10	0.4%
5.B Biological Treatment of Soild Waste		N2O	139.20	253.89	0.000	0.0%	0.0001	0.0%	121%	0.21	0.4%	0.09	0.3%
5.C Incineration and Open Burning of Waste		CO2	12,424.36	12,345.82	0.009	0.9%	0.0004	0.1%	15%	1.30	2.5%	0.07	0.2%
5.C Incineration and Open Burning of Waste		CH4	16.05	10.71	0.000	0.0%	0.0000	0.0%	163%	0.01	0.0%	0.01	0.0%
5.C Incineration and Open Burning of Waste		N2O	1,435.25	1,435.89	0.001	0.1%	0.0000	0.0%	76%	0.76	1.4%	0.03	0.1%
5.D Wastewater Treatment and Discharge		CH4	2,859.83	1,686.58	0.001	0.1%	0.0009	0.2%	22%	0.26	0.5%	0.19	0.7%
5.D Wastewater Treatment and Discharge		N2O	1,206.92	1,123.89	0.001	0.1%	0.0001	0.0%	59%	0.46	0.9%	0.06	0.2%
5.E Other		CO2	702.83	616.69	0.000	0.0%	0.0001	0.0%	10%	0.04	0.1%	0.01	0.0%
Absolute Figure Total (including LULUCF)			1,372,351.50	1,438,121.73	1.00	100.0%	0.45	100%		52.42	100.0%	28.95	100.0%

Table A1-10 Data used for the key category analysis (FY1990)

A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO_2eq.]	E Ap1-L	F % Ap1-L Contrib.	I Source/Sink Uncertainty	J Ap2-L	K % Ap2-L Contrib.
1.A.1. Energy Industries	Liquid Fuels	CO2	173,981.30	0.127	12.7%	2%	2.88	0.04
1.A.1. Energy Industries	Solid Fuels	CO2	92,981.82	0.068	6.8%	3%	2.22	0.03
1.A.1. Energy Industries	Gaseous Fuels	CO2	79,141.15	0.058	5.8%	1%	0.59	0.01
1.A.1. Energy Industries	Other Fossil Fuels	CO2	6,678.58	0.005	0.5%	15%	0.75	0.01
1.A.1. Energy Industries		CH4	431.46	0.000	0.0%	44%	0.14	0.00
1.A.1. Energy Industries		N2O	1,197.14	0.001	0.1%	36%	0.32	0.00
1.A.2. Manufacturing Industries and	Liquid Fuels	CO2	155,177.06	0.113	11.3%	2%	2.57	0.04
1.A.2. Manufacturing Industries and	Solid Fuels	CO2	207,261.86	0.151	15.1%	3%	4.95	0.08
1.A.2. Manufacturing Industries and	Gaseous Fuels	CO2	13,502.24	0.010	1.0%	1%	0.10	0.00
1.A.2. Manufacturing Industries and	Other Fossil Fuels	CO2	4,170.07	0.003	0.3%	15%	0.47	0.01
1.A.2. Manufacturing Industries and		CH4	441.22	0.000	0.0%	44%	0.14	0.00
1.A.2. Manufacturing Industries and		N2O	1,384.24	0.001	0.1%	36%	0.36	0.01
1.A.3. Transport	a. Domestic Aviation	CO2	7,162.41	0.005	0.5%	2%	0.12	0.00
1.A.3. Transport	a. Domestic Aviation	CH4	5.64	0.000	0.0%	79%	0.00	0.00
1.A.3. Transport	a. Domestic Aviation	N2O	64.02	0.000	0.0%	110%	0.05	0.00
1.A.3. Transport	b. Road Transportation	CO2	178,442.29	0.130	13.0%	2%	2.95	0.05
1.A.3. Transport	b. Road Transportation	CH4	252.59	0.000	0.0%	70%	0.13	0.00
1.A.3. Transport	b. Road Transportation	N2O	3,457.24	0.003	0.3%	72%	1.81	0.03
1.A.3. Transport	c. Railways	CO2	935.40	0.001	0.1%	2%	0.02	0.00
1.A.3. Transport	c. Railways	CH4	1.34	0.000	0.0%	105%	0.00	0.00
1.A.3. Transport	c. Railways	N2O	109.95	0.000	0.0%	125%	0.10	0.00
1.A.3. Transport	d. Domestic Navigation	CO2	13,674.88	0.010	1.0%	2%	0.23	0.00
1.A.3. Transport	d. Domestic Navigation	CH4	31.73	0.000	0.0%	52%	0.01	0.00
1.A.3. Transport	d. Domestic Navigation	N2O	108.07	0.000	0.0%	91%	0.07	0.00
1.A.4. Other Sectors	Liquid Fuels	CO2	115,359.49	0.084	8.4%	2%	1.91	0.03
1.A.4. Other Sectors	Solid Fuels	CO2	5,721.10	0.004	0.4%	3%	0.14	0.00
1.A.4. Other Sectors	Gaseous Fuels	CO2	23,892.27	0.017	1.7%	1%	0.18	0.00
1.A.4. Other Sectors	Other Fossil Fuels	CO2	0.00	0.000	0.0%	15%	0.00	0.00
1.A.4. Other Sectors		CH4	255.03	0.000	0.0%	44%	0.08	0.00
1.A.4. Other Sectors		N2O	249.16	0.000	0.0%	36%	0.07	0.00
1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CO2	5.32	0.000	0.0%	71%	0.00	0.00
1.B Fugitive Emission from Fuel	1.Fugitive emissions from Solid Fuels	CH4	4,760.38	0.003	0.3%	66%	2.31	0.04
1.B Fugitive Emission from Fuel	2.a. Oil	CO2	0.03	0.000	0.0%	89%	0.00	0.00
1.B Fugitive Emission from Fuel	2.a. Oil	CH4	25.36	0.000	0.0%	69%	0.01	0.00
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CO2	0.63	0.000	0.0%	80%	0.00	0.00
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CH4	174.24	0.000	0.0%	73%	0.09	0.00
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CO2	81.17	0.000	0.0%	14%	0.01	0.00
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CH4	7.96	0.000	0.0%	49%	0.00	0.00
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	N2O	0.11	0.000	0.0%	32%	0.00	0.00
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CO2	104.42	0.000	0.0%	17%	0.01	0.00
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CH4	5.21	0.000	0.0%	17%	0.00	0.00

Table A1-10 Data used for the key category analysis (FY1990) (Continue)

A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO_2eq.]	E Ap1-L	F % Ap1-L Contrib.	I Source/Sink Uncertainty	J Ap2-L	K % Ap2-L Contrib.
2.A Mineral Product	1. Cement Production	CO2	38,701.10	0.028	2.8%	4%	1.16	0.02
2.A Mineral Product	2. Lime Production	CO2	6,674.45	0.005	0.5%	4%	0.18	0.00
2.A Mineral Product	3. Glass Production	CO2	153.24	0.000	0.0%	6%	0.01	0.00
2.A Mineral Product	4. Other Process Uses of Carbonates	CO2	3,689.87	0.003	0.3%	6%	0.16	0.00
2.B Chemical Industry	1. Ammonia Production	CO2	3,415.96	0.002	0.2%	1%	0.03	0.00
2.B Chemical Industry	Other products except Anmonia	CO2	3,620.20	0.003	0.3%	55%	1.45	0.02
2.B Chemical Industry	2. Nitric Acid Production	N2O	736.06	0.001	0.1%	73%	0.39	0.01
2.B Chemical Industry	3. Adipic Acid Production	N2O	7,210.88	0.005	0.5%	9%	0.48	0.01
2.B Chemical Industry	4. Caprolactam, Glyoxal and Glyoxylic Acid	N2O	1,672.86	0.001	0.1%	99%	1.20	0.02
2.B Chemical Industry	9. Fluorochemical Production (Fugitive	HFCs	15,930.24	0.012	1.2%	2%	0.23	0.00
2.B Chemical Industry	9. Fluorochemical Production (Fugitive	PFCs	330.92	0.000	0.0%	2%	0.00	0.00
2.B Chemical Industry	9. Fluorochemical Production (Fugitive	SF6	3,470.78	0.003	0.3%	2%	0.05	0.00
2.B Chemical Industry	9. Fluorochemical Production (Fugitive	NF3	3.07	0.000	0.0%	2%	0.00	0.00
2.B Chemical Industry	whole of Chemical Industries	CH4	37.49	0.000	0.0%	55%	0.01	0.00
2.C Metal Production	1 Iron and Steel Production	CO2	7,272.76	0.005	0.5%	4%	0.19	0.00
2.C Metal Production	1 Iron and Steel Production	CH4	18.42	0.000	0.0%	163%	0.02	0.00
2.C Metal Production	2. Ferroalloys Production	CH4	4.63	0.000	0.0%	163%	0.01	0.00
2.C Metal Production	3. Aluminium Production	PFCs	203.66	0.000	0.0%	44%	0.07	0.00
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium	HFCs	0.00	0.000	0.0%	5%	0.00	0.00
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium	SF6	146.54	0.000	0.0%	5%	0.01	0.00
2.D Non-energy Products from Fuels and		CO2	392.21	0.000	0.0%	39%	0.11	0.00
2.E Electronics Industry		HFCs	0.73	0.000	0.0%	100%	0.00	0.00
2.E Electronics Industry		PFCs	1,454.78	0.001	0.1%	81%	0.85	0.01
2.E Electronics Industry		SF6	418.70	0.000	0.0%	300%	0.92	0.01
2.E Electronics Industry		NF3	29.82	0.000	0.0%	71%	0.02	0.00
2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	0.00	0.000	0.0%	7%	0.00	0.00
2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	1.34	0.000	0.0%	50%	0.00	0.00
2.F Product uses as substitutes for ODS	3. Fire Extinguishers	HFCs	0.00	0.000	0.0%	16%	0.00	0.00
2.F Product uses as substitutes for ODS	4. Aerosols	HFCs	0.00	0.000	0.0%	10%	0.00	0.00
2.F Product uses as substitutes for ODS	5. Solvents	HFCs	0.00	0.000	0.0%	32%	0.00	0.00
2.F Product uses as substitutes for ODS	5. Solvents	PFCs	4,549.94	0.003	0.3%	10%	0.33	0.01
2.G Other Product Manufacture and Use		N2O	290.86	0.000	0.0%	4%	0.01	0.00
2.G Other Product Manufacture and Use		PFCs	0.00	0.000	0.0%	10%	0.00	0.00
2.G Other Product Manufacture and Use		SF6	8,814.04	0.006	0.6%	76%	4.86	0.07
2.H Other	Use of Dry Ice	CO2	64.27	0.000	0.0%	5%	0.00	0.00
3.A Enteric Fermentation		CH4	9,064.25	0.007	0.7%	25%	1.68	0.03
3.B Manure Management		CH4	3,353.17	0.002	0.2%	17%	0.42	0.01
3.B Manure Management		N2O	4,249.17	0.003	0.3%	82%	2.53	0.04
3.C Rice Cultivation		CH4	17,294.01	0.013	1.3%	6%	0.77	0.01
3.D Agricultural Soils	1. Direct Emissions	N2O	4,789.26	0.003	0.3%	27%	0.93	0.01
3.D Agricultural Soils	2. Indirect Emissions	N2O	2,472.78	0.002	0.2%	164%	2.95	0.05
3.F Field Burning of Agricultural Residues		CH4	127.03	0.000	0.0%	296%	0.27	0.00
3.F Field Burning of Agricultural Residues		N2O	39.26	0.000	0.0%	300%	0.09	0.00
3.G Liming		CO2	550.24	0.000	0.0%	50%	0.20	0.00
3.H Urea Application		CO2	58.64	0.000	0.0%	50%	0.02	0.00
4.A Forest Land	1. Forest Land remaining Forest Land	CO2	76,996.51	0.056	5.6%	12%	7.01	0.11
4.A Forest Land	2. Land converted to Forest Land	CO2	2,076.62	0.002	0.2%	12%	0.19	0.00
4.B Cropland	1. Cropland remaining Cropland	CO2	10,133.99	0.007	0.7%	33%	2.45	0.04
4.B Cropland	2. Land converted to Cropland	CO2	1,972.65	0.001	0.1%	18%	0.26	0.00
4.C Grassland	1. Grassland remaining Grassland	CO2	891.81	0.001	0.1%	9%	0.06	0.00
4.C Grassland	2. Land converted to Grassland	CO2	218.86	0.000	0.0%	18%	0.03	0.00
4.D Wetlands	1.1 Peat Extraction Remaining Peat	CO2	0.00	0.000	0.0%	21%	0.00	0.00
4.D Wetlands	1.2 Flooded Land Remaining Flooded Land	CO2	0.00	0.000	0.0%	21%	0.00	0.00
4.D Wetlands	1.3 Other Wetlands Remaining Other	CO2	0.00	0.000	0.0%	21%	0.00	0.00
4.D Wetlands	2. Land converted to Wetlands	CO2	84.65	0.000	0.0%	21%	0.01	0.00
4.E Settlements	1. Settlements remaining Settlements	CO2	1,378.73	0.001	0.1%	34%	0.34	0.01
4.E Settlements	2. Land converted to Settlements	CO2	5,231.62	0.004	0.4%	21%	0.79	0.01
4.F Other Land	1. Other Land remaining Other Land	CO2	0.00	0.000	0.0%	17%	0.00	0.00
4.F Other Land	2. Land converted to Other Land	CO2	1,454.57	0.001	0.1%	17%	0.18	0.00
4.G Harvested Wood Products		CO2	856.72	0.001	0.1%	30%	0.19	0.00
4(I). Direct N2O emissions from N inputs to managed soils		N2O	0.84	0.000	0.0%	31%	0.00	0.00
4(II).Drainage and rewetting		CO2	0.00	0.000	0.0%	0%	0.00	0.00
4(II).Drainage and rewetting		CH4	38.75	0.000	0.0%	115%	0.03	0.00
4(II).Drainage and rewetting		N2O	0.00	0.000	0.0%	0%	0.00	0.00
4(III).Direct N2O emissions from N mineralization/immobilization		N2O	189.11	0.000	0.0%	138%	0.19	0.00
4(IV) Indirect N2O Emissions from Managed Soils		N2O	40.61	0.000	0.0%	318%	0.09	0.00
4(V) Biomass Burning		CO2	0.00	0.000	0.0%	0%	0.00	0.00
4(V) Biomass Burning		CH4	34.22	0.000	0.0%	28%	0.01	0.00
4(V) Biomass Burning		N2O	8.30	0.000	0.0%	296%	0.02	0.00
5.A Solid Waste Disposal		CH4	9,220.70	0.007	0.7%	23%	1.56	0.02
5.B Biological Treatment of Soild Waste		CH4	194.63	0.000	0.0%	104%	0.15	0.00
5.B Biological Treatment of Soild Waste		N2O	139.20	0.000	0.0%	121%	0.12	0.00
5.C Incineration and Open Burning of Waste		CO2	12,424.36	0.009	0.9%	15%	1.37	0.02
5.C Incineration and Open Burning of Waste		CH4	16.05	0.000	0.0%	163%	0.02	0.00
5.C Incineration and Open Burning of Waste		N2O	1,435.25	0.001	0.1%	76%	0.79	0.01
5.D Wastewater Treatment and Discharge		CH4	2,859.83	0.002	0.2%	22%	0.47	0.01
5.D Wastewater Treatment and Discharge		N2O	1,206.92	0.001	0.1%	59%	0.52	0.01
5.E Other		CO2	702.83	0.001	0.1%	10%	0.05	0.00
Absolute Figure Total (including LULUCF)			1,372,351.50	1.00	100.0%		65.32	1.00

Annex 2. Assessment of Uncertainty

A2.1. Methodology of Uncertainty Assessment

"Uncertainty" is a conceptual framework which represents the differences between emissions/ removals inventory estimates and true underlying values, resulting from lack of data or representativeness, sampling error, or, errors in measurement values, etc. In the paragraph 15 and 42 in the "*Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention"* (Decision 24/CP.19), it is noted that Annex I Parties shall quantitatively estimate and report the uncertainty of inventories. The assessment of uncertainties is intended to contribute to improve the accuracy of national inventories continuously and to guide decisions on methodological choice but not to evaluate justification of inventories nor make a comparison of accuracy of inventories among the parties.

The fundamental methodological issues of uncertainties assessment are provided in the IPCC guidelines; however, uncertainty assessment for specific emission sources and removal sinks is mainly subject to country-specific method determined by each party depending on country's own circumstances. In Japan, uncertainty assessments have been reviewed by the Committee for the Greenhouse Gases Emissions Estimation Methods in FY2001, FY2006, FY2012 and FY2014. For the National Inventory Reports submitted this time, the uncertainties in emission/removal inventories were assessed based on the country-specific guidelines revised in FY2014.

A2.2. Results of Uncertainty Assessment

A2.2.1. Uncertainty of Japan's Total Emissions

In FY2014, total net emissions in Japan were approximately 1,302 million tons (carbon dioxide equivalents). Uncertainty of total net emissions in FY2014 has been assessed at -2% to +2% and uncertainty introduced into the trend in total net emissions has been assessed at -3% to +2%. Thus, the uncertainty level was low in Japan, mainly because CO_2 emissions from low-uncertainty fuel combustion (1.A.) accounted for 95% of the net emissions.

Table A2-1 Uncertainty of Japan's total net emissions

A	B	C	D	G-1990		G-2014		I	J	
Category	Gas	Base year emissions / removals	2014 emissions / removals	Combined uncertainty in 1990		Combined uncertainty in 2014		Inventory trend in national emissions for 2014 increase with respect to 1990	Uncertainty introduced into the trend in total national emissions	
		kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(+) %	%	(-) %	(+) %
1A. Fuel Combustion (CO_2)	CO_2	1,078,082	1,205,408	-2%	+1%	-2%	+1%	11.8%	-2.6%	+1.7%
1A. Fuel Combustion (Stationary:CH_4,N_2O)	CH_4, N_2O	3,958	6,196	-28%	+30%	-29%	+30%	56.5%	0.0%	+0.0%
1A. Fuel Combustion (Transport:CH_4,N_2O)	CH_4, N_2O	4,031	1,861	-32%	+92%	-29%	+86%	-53.8%	0.0%	+0.0%
1B. Fugitive Emissions from Fuels	CO_2, CH_4, N_2O	5,165	1,233	-40%	+83%	-23%	+42%	-76.1%	0.0%	+0.0%
2. IPPU (CO_2,CH_4,N_2O)	CO_2, CH_4, N_2O	73,955	47,608	-4%	+4%	-4%	+4%	-35.6%	-0.1%	+0.1%
2. IPPU (HFCs,PFCs,SF_6,NF_3)	HFCs, PFCs, SF_6, NF_3	35,355	42,042	-7%	+33%	-7%	+9%	18.9%	-0.4%	+0.4%
3. Agriculture	CO_2, CH_4, N_2O	41,998	38,372	-9%	+22%	-8%	+20%	-8.6%	0.0%	+0.0%
4. LULUCF	CO_2, CH_4, N_2O	-59,295	-61,463	-17%	+17%	-13%	+13%	3.7%	-0.4%	+0.4%
5. Waste	CO_2, CH_4, N_2O	28,200	21,142	-11%	+11%	-11%	+12%	-25.0%	-0.2%	+0.2%
Total Net Emissions		1,211,448	1,302,399	-+2.2%	+1.9%	-+1.9%	+1.5%	7.5%	-2.6%	+1.8%

Data used for estimating emissions in each category are as follows:

Table A2-2 Data used for uncertainty assessment (Energy)

A		B	C	D	E		F		G	H-1990		H-2014		T	I	J	K		L		M
Category		Gas	1990 emissions / removals	2014 emissions / removals	Activity data uncertainty		Emission factor/ estimation parameter uncertainty		Combined uncertainty	Combined Uncertainty as % of Total National Emissions in 1990		Combined Uncertainty as % of Total National Emissions in 2014		Emission increase rate	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty		Uncertainty in trend in national emissions introduced by activity data uncertainty		Uncertainty introduced into the trend in total national emissions
			Input Data	Input Data	Input Data		Input Data		$(E^2+F^2)^{1/2}$	G*D/ΣD		G*D/ΣD		D/C	Note A	D/ΣC	I*F		J*E*γ/2		$(K^2+L^2)^{1/2}$
			kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(+) %	(-) %	(-)	(+)	(-)	(+)	%	%	%	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %
Total			1,211,448	1,302,399						-2.2%	+1.9%	-1.9%	+1.5%	7.5%							-2.6%	+1.8%
1.A. Fuel Combustion	Liquid Fuels	CO2	644,730	461,428	-3%	+1%	-	-	-3%	+1%	-1.7%	0.7%	-1.1%	0.5%	-28.4%	0.2%	38.1%	0.0%	0.0%	-1.6%	0.5%	1.6%	0.5%
1.A. Fuel Combustion	Solid Fuels	CO2	305,968	463,276	-4%	+3%	-	-	-4%	+3%	-0.9%	0.7%	-1.3%	1.0%	51.4%	0.1%	38.2%	0.0%	0.0%	-2.0%	1.5%	2.0%	1.5%
1.A. Fuel Combustion	Gaseous Fuels	CO2	116,536	264,853	-1%	+1%	-	-	-1%	+1%	-0.1%	0.1%	-0.2%	0.2%	127.3%	0.1%	21.9%	0.0%	0.0%	-0.3%	0.3%	0.3%	0.3%
1.A. Fuel Combustion	Other Fossil Fuels	CO2	10,849	15,851	-	-	-	-	-15%	15%	-0.1%	0.1%	-0.2%	0.2%	46.1%	0.0%	1.3%	NA	NA	NA	NA	0.0%	0.0%
1.A. Stationary Combustion		CH4	1,128	1,553	-	-	-	-	-38%	+49%	0.0%	0.0%	0.0%	0.1%	37.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A. Stationary Combustion		N2O	2,831	4,643	-	-	-	-	-36%	+36%	-0.1%	0.1%	-0.1%	0.1%	64.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	a. Domestic Aviation	CH4	6	2	-5%	+5%	-57%	+100%	-57%	+100%	0.0%	0.0%	0.0%	0.0%	-69.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	a. Domestic Aviation	N2O	64	90	-5%	+5%	-70%	+150%	-70%	+150%	0.0%	0.0%	0.0%	0.0%	40.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	b. Road Transportation	CH4	253	127	-	-	-	-	-36%	104%	0.0%	0.0%	0.0%	0.0%	-49.6%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.A.3. Transport	b. Road Transportation	N2O	3,457	1,471	-	-	-	-	-37%	107%	-0.1%	0.3%	0.0%	0.1%	-57.4%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	c. Railways	CH4	1	1	-5%	+5%	-60%	+151%	-60%	+151%	0.0%	0.0%	0.0%	0.0%	-43.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	c. Railways	N2O	110	62	-5%	+5%	-50%	+200%	-50%	+200%	0.0%	0.0%	0.0%	0.0%	-43.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	d. Domestic Navigation	CH4	32	24	-13%	+13%	-50%	+50%	-52%	+52%	0.0%	0.0%	0.0%	0.0%	-23.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.A.3. Transport	d. Domestic Navigation	N2O	108	83	-13%	+13%	-40%	+140%	-42%	+141%	0.0%	0.0%	0.0%	0.0%	-23.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.B Fugitive Emission from Fuel	1.Solid Fuels	CO2	5.3	0.5	-	-	-	-	-46%	+95%	0.0%	0.0%	0.0%	0.0%	-90.8%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	1.Solid Fuels	CH4	4,760	539	-	-	-	-	-43%	+90%	-0.2%	0.4%	0.0%	0.0%	-88.7%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.a. Oil	CO2	0.03	-	-	-	-	-	-89%	+89%	0.0%	0.0%	0.0%	0.0%	-18.8%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.a. Oil	CH4	25	22	-	-	-	-	-69%	+69%	0.0%	0.0%	0.0%	0.0%	-12.6%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CO2	1	1	-	-	-	-	-80%	+80%	0.0%	0.0%	0.0%	0.0%	35.7%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.b. Natural Gas	CH4	174	230	-	-	-	-	-70%	+76%	0.0%	0.0%	0.0%	0.0%	31.8%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CO2	81	210	-	-	-	-	-14%	+14%	0.0%	0.0%	0.0%	0.0%	158.5%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	CH4	8	5	-	-	-	-	-49%	+49%	0.0%	0.0%	0.0%	0.0%	-36.9%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.c. Venting & Flaring	N2O	0.1	0.1	-	-	-	-	-32%	+32%	0.0%	0.0%	0.0%	0.0%	-19.3%	0.0%	0.0%	NA	NA	NA	NA	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CO2	104	215	-7%	+7%	-15%	+15%	-17%	+17%	0.0%	0.0%	0.0%	0.0%	106.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1.B Fugitive Emission from Fuel	2.d. Other (Geothermal)	CH4	5	11	-7%	+7%	-15%	+15%	-17%	+17%	0.0%	0.0%	0.0%	0.0%	101.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A2-3 Data used for uncertainty assessment (Industrial Processes)

A		B	C	D	E		F		G		H-1990		H-2014		T	I	J	K		L		M
Category		Gas	1990 emissions / removals	2014 emissions / removals	Activity data uncertainty		Emission factor/ estimation parameter uncertainty		Combined uncertainty		Combined Uncertainty as % of Total National Emissions in 1990		Combined Uncertainty as % of Total National Emissions in 2014		Emission increase rate	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty		Uncertainty in trend in national emissions introduced by activity data uncertainty		Uncertainty introduced into the trend in total national emissions
			Input Data	Input Data	Input Data		Input Data		$(E^2+F^2)^{1/2}$		G*D/ Σ D		G*D/ Σ D		D/C	Note A	D/Σ C	I*F		J*E*√2		$(K^2+L^2)^{1/2}$
			kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %	(-)	(+)	(-)	(+)	%	%	%	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %
2.A Mineral Product	1. Cement Production	CO2	38,701	26,557	-2%	+2%	-4%	+4%	-4%	+4%	-0.1%	0.1%	-0.1%	0.1%	-31.4%	0.0%	2.2%	0.0%	0.0%	-0.1%	0.1%	-0.1%	0.1%
2.A Mineral Product	2. Lime Production	CO2	6,674	5,922	-3%	+3%	-2%	+2%	-4%	+4%	0.0%	0.0%	0.0%	0.0%	-11.3%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.A Mineral Product	3. Glass Production	CO2	153	93	-3%	+3%	-5%	+5%	-6%	+6%	0.0%	0.0%	0.0%	0.0%	-39.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.A Mineral Product	4. Other Process Uses of Carbonates	CO2	3,690	2,351	-3%	+3%	-5%	+5%	-6%	+6%	0.0%	0.0%	0.0%	0.0%	-36.3%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	1. Ammonia Production	CO2	3,416	1,891	-	-	-	-	-2%	+1%	0.0%	0.0%	0.0%	0.0%	-44.6%	0.0%	0.2%	NA	NA	NA	NA	NA	0.0%
2.B Chemical Industry	Other Production Except Ammonia	CO2	3,620	2,791	-	-	-	-	-55%	+55%	-0.2%	0.2%	-0.1%	0.1%	-22.9%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	2. Nitric Acid Production	N2O	736	461	-2%	+2%	-73%	+73%	-73%	+73%	0.0%	0.0%	0.0%	0.0%	-37.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	3. Adipic Acid Production	N2O	7,211	143	-2%	+2%	-9%	+9%	-9%	+9%	-0.1%	0.1%	0.0%	0.0%	-98.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	4. Caprolactam Production	N2O	1,673	474	-2%	+2%	-99%	+99%	-99%	+99%	-0.1%	0.1%	0.0%	0.0%	-71.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	Whole of Chemical Industries	CH4	37	25	-	-	-	-	-58%	+51%	0.0%	0.0%	0.0%	0.0%	-32.7%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.C Metal Production	1 Iron and Steel Production	CO2	7,273	6,135	-	-	-	-	-4%	+4%	0.0%	0.0%	0.0%	0.0%	-15.6%	0.0%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.C Metal Production	1 Iron and Steel Production	CH4	18	15	-5%	+5%	-163%	+163%	-163%	+163%	0.0%	0.0%	0.0%	0.0%	-19.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.C Metal Production	2. Ferroalloys Production	CH4	5	3	-5%	+5%	-163%	+163%	-163%	+163%	0.0%	0.0%	0.0%	0.0%	-37.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.D Non-energy Products from Fuels and Solvent Use		CO2	392	295	-	-	-	-	-39%	+39%	0.0%	0.0%	0.0%	0.0%	-24.8%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.G Other Product Manufacture and Use		N2O	291	371	-	-	-	-	-4%	+4%	0.0%	0.0%	0.0%	0.0%	27.6%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.H Other	Use of Dry Ice	CO2	64	80	-5%	+5%	-	-	-5%	+5%	0.0%	0.0%	0.0%	0.0%	25.2%	0.0%	0.0%	NA	NA	0.0%	0.0%	0.0%	0.0%
2.B Chemical Industry	9. Fluorochemical Production (By-product emissions)	HFCs	15,929	24	-	-	-	-	-2%	+2%	0.0%	0.0%	0.0%	0.0%	-99.9%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	HFCs	2	101	-	-	-	-	-2%	+2%	0.0%	0.0%	0.0%	0.0%	6556.5%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	PFCs	331	107	-	-	-	-	-2%	+2%	0.0%	0.0%	0.0%	0.0%	-67.6%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	SF6	3,471	62	-	-	-	-	-2%	+2%	0.0%	0.0%	0.0%	0.0%	-98.2%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.B Chemical Industry	9. Fluorochemical Production (Fugitive Emissions)	NF3	3	673	-	-	-	-	-2%	+2%	0.0%	0.0%	0.0%	0.0%	21820%	0.0%	0.1%	NA	NA	NA	NA	NA	0.0%
2.C Metal Production	3. Aluminium Production	PFCs	204	2	-2%	+2%	-44%	+44%	-44%	+44%	0.0%	0.0%	0.0%	0.0%	-99.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	HFCs	0	1	-	-	-	-	-5%	+5%	0.0%	0.0%	0.0%	0.0%	NA	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	SF6	147	182	-	-	-	-	-5%	+5%	0.0%	0.0%	0.0%	0.0%	24.5%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.E Electronics Industry		HFCs	1	115	-10%	+10%	-100%	+100%	-100%	+100%	0.0%	0.0%	0.0%	0.0%	15629%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.E Electronics Industry		PFCs	1,455	1,707	-10%	+10%	-80%	+80%	-81%	+81%	-0.1%	0.1%	-0.1%	0.1%	17.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.E Electronics Industry		SF6	419	366	-10%	+10%	-300%	+300%	-300%	+300%	-0.1%	0.1%	-0.1%	0.1%	-12.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.E Electronics Industry		NF3	30	158	-10%	+10%	-70%	+70%	-71%	+71%	0.0%	0.0%	0.0%	0.0%	430.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	1. Refrigeration and Air conditioning	HFCs	0	32,556	-	-	-	-	-7%	+7%	0.0%	0.0%	-0.2%	0.2%	NA	0.0%	2.7%	0.0%	0.0%	-0.4%	0.4%	0.4%	0.4%
2.F Product uses as substitutes for ODS	2. Foam Blowing Agents	HFCs	1	2,373	-	-	-	-	-50%	+50%	0.0%	0.0%	-0.1%	0.1%	17673136%	0.0%	0.2%	NA	NA	NA	NA	NA	0.0%
2.F Product uses as substitutes for ODS	3. Fire Extinguishers	HFCs	NO	9	-	-	-	-	-16%	+16%	NA	NA	0.0%	0.0%	NA	NA	0.0%	NA	NA	NA	NA	NA	0.0%
2.F Product uses as substitutes for ODS	4. Aerosols	HFCs	0	503	-	-	-	-	-10%	+10%	0.0%	0.0%	0.0%	0.0%	NA	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
2.F Product uses as substitutes for ODS	5. Solvents	HFCs	0	103	-10%	+10%	-30%	+30%	-32%	+32%	0.0%	0.0%	0.0%	0.0%	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2.F Product uses as substitutes for ODS	5. Solvents	PFCs	4,550	1,537	-10%	+10%	-	-	-10%	+10%	0.0%	0.0%	0.0%	0.0%	-66.2%	0.0%	0.1%	NA	NA	0.0%	0.0%	0.0%	0.0%
2.G Other Product Manufacture and Use		PFCs	0	9	-10%	+10%	-	-	-10%	+10%	0.0%	0.0%	0.0%	0.0%	NA	0.0%	0.0%	NA	NA	0.0%	0.0%	0.0%	0.0%
2.G Other Product Manufacture and Use		SF6	8,814	1,455	-	-	-	-	-20%	+131%	-0.1%	1.0%	0.0%	0.1%	-83.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A2-4 Data used for uncertainty assessment (Agriculture)

A		B	C	D	E		F		G	H-1990		H-2014		T	I	J	K		L		M
Category		Gas	1990 emissions / removals	2014 emissions / removals	Activity data uncertainty		Emission factor/ estimation parameter uncertainty		Combined uncertainty	Combined Uncertainty as % of Total National Emissions in 1990		Combined Uncertainty as % of Total National Emissions in 2014		Emission increase rate	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty		Uncertainty in trend in national emissions introduced by activity data uncertainty		Uncertainty introduced into the trend in total national emissions
			Input Data	Input Data	Input Data		Input Data		$(E^2+F^2)^{1/2}$	G*D/ΣD		G*D/ΣD		D/C	Note A	D/ΣC	I*F		J*E*√2		$(K^2+L^2)^{1/2}$
			kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(+) %	(-) %	(-)	(+)	(-)	(+)	%	%	%	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %
3.A Enteric Fermentation	Dairy cattle	CH4	4,652	3,399	-1%	+1%	-26%	+32%	-26%	-0.1%	0.1%	-0.1%	0.1%	-26.9%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
3.A Enteric Fermentation	Non-dairy cattle	CH4	3,956	3,450	-1%	+1%	-40%	+49%	-40%	-0.1%	0.2%	-0.1%	0.1%	-12.8%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
3.A Enteric Fermentation	Sheep	CH4	4	3	-9%	+9%	-50%	+50%	-51%	0.0%	0.0%	0.0%	0.0%	-17.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.A Enteric Fermentation	Swine	CH4	397	334	-1%	+1%	-69%	+69%	-69%	0.0%	0.0%	0.0%	0.0%	-15.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.A Enteric Fermentation	Other Livestock	CH4	56	36	-9%	+9%	-50%	+50%	-51%	0.0%	0.0%	0.0%	0.0%	-35.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Dairy cattle	CH4	2,900	2,022	-1%	+1%	-20%	+20%	-20%	0.0%	0.0%	0.0%	0.0%	-30.3%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Dairy cattle	N2O	734	747	-1%	+1%	-71%	+112%	-71%	0.0%	0.1%	0.0%	0.1%	1.8%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Non-dairy cattle	CH4	108	134	-1%	+1%	-20%	+20%	-20%	0.0%	0.0%	0.0%	0.0%	24.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Non-dairy cattle	N2O	837	861	-1%	+1%	-71%	+112%	-71%	0.0%	0.1%	0.0%	0.1%	2.9%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Sheep	CH4	0.1	0.1	-9%	+9%	-30%	+30%	-31%	0.0%	0.0%	0.0%	0.0%	-17.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Sheep	N2O	0	0	-9%	+9%	-71%	+112%	-72%	0.0%	0.0%	0.0%	0.0%	NA	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Swine	CH4	278	123	-1%	+1%	-20%	+20%	-20%	0.0%	0.0%	0.0%	0.0%	-55.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Swine	N2O	894	1,182	-1%	+1%	-71%	+112%	-71%	0.1%	-0.1%	0.1%	0.1%	32.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Poultry	CH4	58	77	-9%	+9%	-20%	+20%	-22%	0.0%	0.0%	0.0%	0.0%	32.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Poultry	N2O	411	524	-9%	+9%	-71%	+112%	-72%	0.0%	0.0%	0.0%	0.0%	27.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Other Livestock	CH4	10	4	-9%	+9%	-30%	+30%	-31%	0.0%	0.0%	0.0%	0.0%	-53.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	Other Livestock	N2O	8	1	-9%	+9%	-71%	+112%	-72%	0.0%	0.0%	0.0%	0.0%	-82.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.B Manure Management	5. Indirect Emissions	N2O	1,365	1,177	-9%	+9%	-106%	+447%	-106%	-0.1%	0.5%	-0.1%	0.4%	-13.8%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.C Rice Cultivation		CH4	17,294	17,904	-1%	+1%	-6%	+6%	-6%	-0.1%	0.1%	-0.1%	0.1%	3.5%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.1. Inorganic Fertilizers	N2O	1,843	1,258	-1%	+1%	-31%	+31%	-31%	0.0%	0.0%	0.0%	0.0%	-31.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.2. Organic Fertilizers	N2O	1,653	1,386	-	-	-	-	-24%	0.0%	0.0%	0.0%	0.0%	-16.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.3. Pasture, Range and Paddock	N2O	58	43	-1%	+1%	-65%	+200%	-65%	+200%	0.0%	0.0%	0.0%	-25.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.4. Crop Residue	N2O	707	600	-1%	+1%	-70%	+200%	-70%	+200%	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.5. Mineralization	N2O	407	367	-1%	+1%	-31%	+31%	-31%	+31%	0.0%	0.0%	0.0%	-9.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	a.6. Plowing of Organic Soils	N2O	121	115	-1%	+1%	-75%	+200%	-75%	+200%	0.0%	0.0%	0.0%	-5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	b.1. Atomospheric Deposition	N2O	819	647	-9%	+9%	-106%	+447%	-106%	+447%	-0.1%	0.3%	-0.1%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.D Agricultural Soils	b.2. N leaching and Run-off	N2O	1,654	1,302	-9%	+9%	-115%	+287%	-115%	+287%	-0.2%	0.4%	-0.1%	0.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
3.F Field Burning of Agricultural Residues		CH4	127	72	-1%	+1%	-296%	+296%	-296%	+296%	0.0%	0.0%	0.0%	-43.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.F Field Burning of Agricultural Residues		N2O	39	22	-1%	+1%	-300%	+300%	-300%	+300%	0.0%	0.0%	0.0%	-43.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.G Liming		CO2	550	380	-1%	+1%	-50%	+50%	-50%	+50%	0.0%	0.0%	0.0%	-31.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3.H Urea Application		CO2	59	198	-1%	+1%	-50%	+50%	-50%	+50%	0.0%	0.0%	0.0%	238.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A2-5 Data used for uncertainty assessment (LULUCF)

A	B	C	D	E	F	G	H-1990		H-2014		T	I	J	K	L	M
Category	Gas	1990 emissions / removals	2014 emissions / removals	Activity data uncertainty	Emission factor/ estimation parameter uncertainty	Combined uncertainty	Combined Uncertainty as % of Total National Emissions in 1990		Combined Uncertainty as % of Total National Emissions in 2014		Emission increase rate	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions
		Input Data	Input Data	Input Data	Input Data	$(E^2+F^2)^{1/2}$	G*D/ Σ D		G*D/ Σ D		D/C	Note A	D/ Σ C	I*F	J*E*√2	$(K^2+L^2)^{1/2}$
		kt-CO_2 eq.	kt-CO_2 eq.	(-) %	(+) %	(-) %	(-)	(+)	(-)	(+)	%	%	%	(-) % (+) %	(-) % (+) %	(-) % (+) %
4.A Forest Land	CO2	-76,997	-65,043	-	-	-12% 12%	-0.8%	0.8%	-0.6%	0.6%	-15.5%	0.0%	5.4%	0.0% 0.0%	-0.4% 0.4%	0.4% 0.4%
4.A Forest Land	CO2	-2,077	-338	-	-	-12% 12%	0.0%	0.0%	0.0%	0.0%	-83.7%	0.0%	0.0%	0.0% 0.0%	0.0% 0.0%	0.0% 0.0%
4.B Cropland	CO2	10,134	4,291	-	-	-33% 33%	-0.3%	0.3%	-0.1%	0.1%	-57.7%	0.0%	0.4%	NA NA	NA NA	0.0% 0.0%
4.B Cropland	CO2	1,973	205	-	-	-18% 18%	0.0%	0.0%	0.0%	0.0%	-89.6%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.C Grassland	CO2	892	-85	-	-	-9% 9%	0.0%	0.0%	0.0%	0.0%	-109.5%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.C Grassland	CO2	219	17	-	-	-18% 18%	0.0%	0.0%	0.0%	0.0%	-92.4%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.D Wetlands	CO2	0	0	-	-	- -	NA	NA	NA	NA	NA	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.D Wetlands	CO2	85	41	-	-	-21% 21%	0.0%	0.0%	0.0%	0.0%	-51.6%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.E Settlements	CO2	-1,379	-1,773	-	-	-34% 34%	0.0%	0.0%	0.0%	0.0%	28.6%	0.0%	0.1%	NA NA	NA NA	0.0% 0.0%
4.E Settlements	CO2	5,232	1,419	-	-	-21% 21%	-0.1%	0.1%	0.0%	0.0%	-72.9%	0.0%	0.1%	NA NA	NA NA	0.0% 0.0%
4.F Other Land	CO2	0	0	-	-	- -	NA	NA	NA	NA	NA	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.F Other Land	CO2	1,455	166	-	-	-17% 17%	0.0%	0.0%	0.0%	0.0%	-88.6%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4.G Harvested Wood Products	CO2	857	-621	-	-	-30% 30%	0.0%	0.0%	0.0%	0.0%	-172.5%	0.0%	0.1%	NA NA	NA NA	0.0% 0.0%
4(I). Direct N2O emissions from N inputs to managed soils	N2O	1	1	-	-	-31% 31%	0.0%	0.0%	0.0%	0.0%	-33.0%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4(II). Emissions and removals from drainage and rewetting	CH4	39	37	-71%	+71%	-90% +90%	0.0%	0.0%	0.0%	0.0%	-4.6%	0.0%	0.0%	0.0% 0.0%	0.0% 0.0%	0.0% 0.0%
4(II). Emissions and removals from drainage and rewetting	N2O	NO,NA	NO,NA	NA	NA	NA NA	NA	NA	NA	NA	NA	NA	NA	NA NA	NA NA	0.0% 0.0%
4(III).Direct N2O emissions from N miner.Forest	N2O	IE	IE	-27%	+27%	-75% +202%	NA	NA	NA	NA	NA	NA	NA	NA NA	NA NA	0.0% 0.0%
4(III).Direct N2O emissions from N miner.Other land	N2O	IE	IE	-27%	+27%	-75% +202%	NA	NA	NA	NA	NA	NA	NA	NA NA	NA NA	0.0% 0.0%
4(III).Direct N2O emissions from N miner.Cropland	N2O	189	143	-	-	-31% 31%	0.0%	0.0%	0.0%	0.0%	-24.2%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4(III).Direct N2O emissions from N miner.Grassland	N2O	IE	IE	-	-	-31% 31%	NA	NA	NA	NA	NA	NA	NA	NA NA	NA NA	0.0% 0.0%
4(IV) Indirect N2O Emissions from Manag.Fertilization on forest	N2O	41	32	-31%	+31%	-140% +492%	-143%	+493%	0.0%	0.0%	-21.9%	0.0%	0.0%	0.0% 0.0%	0.0% 0.0%	0.0% 0.0%
4(IV) Indirect N2O Emissions from Manag.Mineralization	N2O	IE	IE	-31%	+31%	-115% +287%	-119%	+288%	NA	NA	NA	NA	NA	NA NA	NA NA	0.0% 0.0%
4(V) Biomass Burning	CH4	10	23	-12%	+12%	-25% +25%	-28%	+28%	0.0%	0.0%	127.5%	0.0%	0.0%	0.0% 0.0%	0.0% 0.0%	0.0% 0.0%
4(V) Biomass Burning	CH4	24	16	-12%	+12%	-29% +29%	-31%	+31%	0.0%	0.0%	-31.9%	0.0%	0.0%	0.0% 0.0%	0.0% 0.0%	0.0% 0.0%
4(V) Biomass Burning	N2O	0.8	1.9	-	-	-296% 296%	0.0%	0.0%	0.0%	0.0%	127.5%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
4(V) Biomass Burning	N2O	7.5	5.1	-	-	-300% 300%	0.0%	0.0%	0.0%	0.0%	-31.9%	0.0%	0.0%	NA NA	NA NA	0.0% 0.0%
Forest																
Cropland (orchard pruning)																

Table A2-6 Data used for uncertainty assessment (Waste)

A		B	C	D	E		F		G		H-1990		H-2014		T	I	J	K		L		M	
Category		Gas	1990 emissions / removals	2014 emissions / removals	Activity data uncertainty		Emission factor/ estimation parameter uncertainty		Combined uncertainty		Combined Uncertainty as % of Total National Emissions in 1990		Combined Uncertainty as % of Total National Emissions in 2014		Emission increase rate	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor/estimation parameter uncertainty		Uncertainty in trend in national emissions introduced by activity data uncertainty		Uncertainty introduced into the trend in total national emissions	
			Input Data	Input Data	Input Data		Input Data		$(E^2+F^2)^{1/2}$		G*D/ΣD		G*D/ΣD		D/C	Note A	%	T*F		J*E*√2		$(K^2+L^2)^{1/2}$	
			kt-CO2 eq.	kt-CO2 eq.	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %	(-)	(+)	(-)	(+)	%	%	%	(-) %	(+) %	(-) %	(+) %	(-) %	(+) %
5.A Solid Waste Disposal	Municipal solid waste	CH4	5,919	2,154	-	-	-	-	-32%	32%	-0.2%	0.2%	-0.1%	0.1%	-63.6%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.A Solid Waste Disposal	Industrial waste	CH4	3,293	1,117	-	-	-	-	-29%	29%	-0.1%	0.1%	0.0%	0.0%	-66.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.A Solid Waste Disposal	Inappropriate disposal	CH4	9	43	-60%	+60%	-42%	+41%	-74%	+73%	0.0%	0.0%	0.0%	0.0%	397.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.B Biological Treatment of Solid Waste		CH4	195	355	-30%	+30%	-99%	+100%	-104%	+104%	0.0%	0.0%	0.0%	0.0%	82.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.B Biological Treatment of Solid Waste		N2O	139	254	-30%	+30%	-67%	+167%	-73%	+169%	0.0%	0.0%	0.0%	0.0%	82.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Municipal Solid Waste		CO2	5,704	3,131	-	-	-	-	-8%	10%	0.0%	0.0%	0.0%	0.0%	-45.1%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (Waste oil)		CO2	3,670	3,856	-30%	+30%	-2%	+2%	-30%	+30%	-0.1%	0.1%	-0.1%	0.1%	5.1%	0.0%	0.3%	0.0%	0.0%	-0.1%	0.1%	0.1%	0.1%
5.C Incineration and Open Burning of Was Industrial Waste (other than Waste oil)		CO2	2,134	4,093	-	-	-	-	-30%	30%	-0.1%	0.1%	-0.1%	0.1%	91.8%	0.0%	0.3%	0.0%	0.0%	-0.1%	0.1%	0.1%	0.1%
5.C Incineration and Open Burning of Was Specially Controlled Industrial Waste		CO2	916	1,265	-60%	+60%	-2%	+2%	-60%	+60%	0.0%	0.0%	-0.1%	0.1%	38.1%	0.0%	0.1%	0.0%	0.0%	-0.1%	0.1%	0.1%	0.1%
5.C Incineration and Open Burning of Was Municipal Solid Waste		CH4	11.6	1.4	-	-	-	-	-29%	52%	0.0%	0.0%	0.0%	0.0%	-87.8%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (Waste oil)		CH4	0.2	0.1	-30%	+30%	-100%	+181%	-104%	+184%	0.0%	0.0%	0.0%	0.0%	-8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (sludge)		CH4	1.8	0.3	-30%	+30%	-100%	+201%	-104%	+203%	0.0%	0.0%	0.0%	0.0%	-86.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (other than Waste oil, sludge)		CH4	2.3	8.3	-	-	-	-	-84%	334%	0.0%	0.0%	0.0%	0.0%	254.3%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
5.C Incineration and Open Burning of Was Specially Controlled Industrial Waste		CH4	0.1	0.6	-60%	+60%	-100%	+216%	-117%	+224%	0.0%	0.0%	0.0%	0.0%	302.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Municipal Solid Waste		N2O	306	135	-	-	-	-	-27%	27%	0.0%	0.0%	0.0%	0.0%	-55.7%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (Waste oil)		N2O	5	26	-30%	+30%	-76%	+76%	-81%	+81%	0.0%	0.0%	0.0%	0.0%	478.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (sludge)		N2O	1,056	1,225	-30%	+30%	-84%	+84%	-89%	+89%	-0.1%	0.1%	-0.1%	0.1%	16.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.C Incineration and Open Burning of Was Industrial Waste (other than Waste oil, sludge)		N2O	64	40	-	-	-	-	-50%	50%	0.0%	0.0%	0.0%	0.0%	-37.9%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
5.C Incineration and Open Burning of Was Specially Controlled Industrial Waste		N2O	6	10	-60%	+60%	-44%	+44%	-74%	+74%	0.0%	0.0%	0.0%	0.0%	68.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Sewage treatment plants		CH4	216	314	-5%	+5%	-31%	+31%	-31%	+31%	0.0%	0.0%	0.0%	0.0%	45.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Domestic wastewater treatment facilities		CH4	846	816	-	-	-	-	-31%	31%	0.0%	0.0%	0.0%	0.0%	-3.5%	0.0%	0.1%	NA	NA	NA	NA	NA	0.0%
5.D Wastewater Treatment and Discharge Human waste treatment facilities		CH4	131	12	-10%	+10%	-84%	+84%	-84%	+84%	0.0%	0.0%	0.0%	0.0%	-91.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Degradation of domestic wastewater in nature		CH4	1,505	430	-10%	+10%	-58%	+58%	-59%	+59%	-0.1%	0.1%	0.0%	0.0%	-71.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge industrial wastewater		CH4	131	107	-30%	+30%	-60%	+60%	-67%	+67%	0.0%	0.0%	0.0%	0.0%	-18.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Landfill leachate treatment		CH4	31	8	-100%	+100%	-39%	+39%	-107%	+107%	0.0%	0.0%	0.0%	0.0%	-74.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Sewage treatment plants		N2O	416	474	-5%	+5%	-100%	+146%	-100%	+146%	0.0%	0.1%	0.0%	0.1%	14.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Domestic wastewater treatment facilities		N2O	470	499	-	-	-	-	-42%	42%	0.0%	0.0%	0.0%	0.0%	6.3%	0.0%	0.0%	NA	NA	NA	NA	NA	0.0%
5.D Wastewater Treatment and Discharge Human waste treatment facilities		N2O	67	4	-10%	+10%	-87%	+87%	-88%	+88%	0.0%	0.0%	0.0%	0.0%	-93.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Degradation of domestic wastewater in nature		N2O	132	34	-10%	+10%	-58%	+58%	-59%	+59%	0.0%	0.0%	0.0%	0.0%	-74.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge industrial wastewater		N2O	115	111	-30%	+30%	-100%	+300%	-104%	+301%	0.0%	0.0%	0.0%	0.0%	-3.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.D Wastewater Treatment and Discharge Landfill leachate treatment		N2O	8	2	-100%	+100%	-39%	+39%	-107%	+107%	0.0%	0.0%	0.0%	0.0%	-74.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5.E Other		CO2	703	617	-10%	+10%	-1%	+1%	-10%	+10%	0.0%	0.0%	0.0%	0.0%	-12.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Note A: Type A sensitivity: $\frac{0.01\times D_x + \sum D_i - \left(0.01\times C_x + \sum C_i\right)}{\left(0.01\times C_x + \sum C_i\right)}\times 100 - \frac{\sum D_i - \sum C_i}{\sum C_i}\times 100$

Where: C_x, D_x = entry of row x of column C and D respectively in the table A2

$\sum C_i, \sum D_i$ = sum of column C and D respectively

Reference

1. IPCC, "2006 IPCC Guidelines" (2006)
2. UNFCCC, "*Revision of the UNFCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention*"
3. Ministry of the Environment, "*Guidelines for Uncertainty Assessment of GHG inventories in Japan*", 2012

Annex 3. Detailed Methodological Descriptions for Individual Source or Sink Categories

A3.1. Methodology for Estimating Emissions of Precursors

In addition to the greenhouse gases (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3) reported under the Convention, Japan reports on the emissions of precursors (NO_X, CO, Non-Methane Volatile Organic Compounds [NMVOC], and SO_X[1]) calculated by established methods. This section explains the source categories for which estimation methodologies were established, and emissions are reported.

Emissions from the source categories for which estimation methods have not been established are considered to be minimal, and accordingly reported as either "NO" or "NE" (or as "IE" as the case may be) based on the results of previous discussion.

A3.1.1 Energy Sector

A3.1.1.1. Stationary Combustion 1.A.1., 1.A.2., 1.A.4.: NO_X, CO, NMVOC, and SO_X

A3.1.1.1.a. Energy Industries (1.A.1), Manufacturing Industries and Construction (1.A.2), Commercial/institutional (1.A.4.a) and Agriculture/forestry/fishing (1.A.4)

a) Category Description

This section provides the estimation methods for emissions of precursors and other substances (NO_X, CO, NMVOC, and SO_X) from Energy industries (1.A.1), Manufacturing industries and construction (1.A.2), Commercial/institutional (1.A.4.a) and Agriculture/forestry/fishing (1.A.4.c).

b) Methodological Issues

1) NO_X and SO_X

- ***Methodology for Estimating Emissions***

➢ ***Facilities emitting soot and smokes***

General Survey of the Emissions of Air Pollutants by Ministry of the Environment was used as NO_X and SO_X emissions from fuel combustion of the facilities emitting soot and smokes specified in laws such as the Air Pollution Control Act. So as to ensure consistency with the categorization of the common reporting format (CRF), the emissions from the energy sector was isolated from the emissions listed in the *General Survey of the Emissions of Air Pollutants* as the following operation:

1. All emissions from the following facilities and industry sectors are reported under Energy:

   Facility: [0101–0103: Boilers]; [0601–0618: Metal rolling furnaces, metal furnaces, and metal forge furnaces]; [1101–1106: Drying ovens]; [2901–3202: Gas turbines, diesel engines, gas engines, and gasoline engines]

[1] Most SO_X consists of SO_2. For major sources, SO_2 emissions are estimated.

Industry sector: [A–D: Accommodation/eating establishments, health care/educational and academic institutions, pubic bathhouses, laundry services]; [F–L: Agriculture/fisheries, mining, construction, electricity, gas, heat distribution, building heating/other operations]

For emissions from the facilities and industry sectors other than the above and [1301–1304: Waste incinerators], after emissions from the Industrial Processes and Product Use (IPPU) sector were identified, the emissions from the Energy sector are estimated by subtracting the emissions of IPPU sector from the emissions listed in the *General Survey of the Emissions of Air Pollutants.* For estimation method in IPPU sector, see A3.1.2.1. Mineral Products, Chemical Industry, Metal Production, and Other Production (2.A., 2.B., 2.C., 2.D.,: NO_X, SO_X)).

➢ ***Small facilities***

NO_X and SO_X emitted by the small facilities (i.e. the facilities in commercial/institutional and manufacturing categories that do not correspond to the facilities emitting soot and smokes) were calculated by multiplying energy consumption in each facility type by Japan's country-specific emission factor.

- ***Emission factors***

➢ ***Facilities emitting soot and smokes***

Not applicable

➢ ***Small facilities***

Emission factors were established for each fuel type for [0102: Heating system boilers] for facilities listed in [L: Heating systems for buildings/other places of business] in the *General Survey of the Emissions of Air Pollutants* by aggregating emission and energy consumption by fuel type.

- ***Activity data***

➢ ***Facilities emitting soot and smokes***

Not applicable

➢ ***Small facilities***

Energy consumption by small facilities by fuel type was calculated by subtracting energy consumption by fuel type, identified by the *General Survey of the Emissions of Air Pollutants*, from energy consumption by fuel type provided in the *General Energy Statistics* (Agency for Natural Resources and Energy). If the activity data shown in the *General Survey of the Emissions of Air Pollutants* exceeded the activity data provided in the *General Energy Statistics*, the activity data for the specified sources was deemed to be zero. The fuels covered were town gas, LPG, kerosene, and fuel oil A.

2) CO and NMVOC

- ***Estimation Method***

Emissions of CO and NMVOC from the specified sources were calculated by multiplying the energy consumption in each facility type by Japan's country-specific emission factor.

- ***Emission factors***

CO emission factors were established based on the summary data in the *Report on Emission Factor Results for Combustion Facilities* (Japan Society for Atmospheric Environment, 1997).

NMVOC emission factors for each facility by fuel type were established by multiplying the CH_4 emission factor by the ratio of NMVOC emission to CH_4 emission factor. The CH_4 emission factors are elaborated in Chapter 3. The NMVOC/CH_4 emission ratios were determined from the report on *Screening Survey Regarding Measures to Counter Global Warming* (Japan Environmental Sanitation Center) and *Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions* (Institute of Behavioral Science).

- ***Activity data***

Energy consumption calculated for estimation of CH_4 and N_2O was used for activity data.

A3.1.1.1.b. Residential sector (1.A.4.b)

a) Category Description

This section provides the estimation methods for emissions of precursors and other substances (NO_X, CO, NMVOC, and SO_X) from fuel combustion of Residence.

b) Methodological Issues

- ***Estimation Method***

NO_X, CO, NMVOC, and SO_X emissions from the target source were calculated by multiplying energy consumed of each fuel type by Japan's country-specific emission factor or the default emission factors from *EMEP/EEA air pollutant emission inventory guidebook 2013*.

- ***Emission factors***

1) NO_X

For solid fuels (steam coal and coal briquettes) and biomass, emission factors were established by converting the default values provided in the *EMEP/EEA air pollutant emission inventory guidebook 2013* to gross calorific values.

For liquid (kerosene) and gaseous (LPG and town gas) fuels, the emission factors by usage by fuel type provided in a report by Air Quality Management Bureau, Environmental Agency were used. This report calculated the emission factors by taking the average of concentration of NO_X emissions by product, obtained through questionnaires and interviews in the household gas appliances industry, weighted by the number of products sold.

2) CO

For solid fuels (steam coal, and coal briquettes), and biomass, emission factors were established by converting the default values provided in the *EMEP/EEA air pollutant emission inventory guidebook 2013* to gross calorific values.

For liquid (kerosene) and gaseous (LPG and town gas) fuels, the emission factors by usage by fuel type provided in the reports by *Report of the Research on the Indirect Greenhouse Gas*

Emission Inventory in FY1996, Institute of Behavioral Science were used. This report tabulated the emission factors by usage by fuel type from the actual values measured in Tokyo, Yokohama city and Chiba Prefecture.

3) NMVOC

For solid fuels (steam coal and coal briquettes), liquid fuels (kerosene), gaseous fuels (LPG and town gas), and biomass, emission factors were established by converting the default values provided in the *EMEP/EEA air pollutant emission inventory guidebook 2013* to gross calorific values.

4) SO_X

For solid fuels (steam coal and coal briquettes), and biomass, emission factors were established by converting the default values provided in the *EMEP/EEA air pollutant emission inventory guidebook 2013* to gross calorific values.

For liquid fuel (kerosene), emission factors were calculated from energy consumption, specific gravity and sulfur content based on the fuel characteristics of kerosene described in information material compiled by the Petroleum Association of Japan.

- ***Activity data***

Fuel consumption by fuel type for residential use in the *General Energy Statistics* has been taken for the activity data. The fuels covered were steam coal, coal briquettes, kerosene, LPG, and town gas. For the ratio of consumption by fuel type by type of use in household, the *Handbook of Energy & Economic Statistics in Japan* (The Energy Data and Modeling Center) is used.

A3.1.1.1.c. Incineration of waste for energy purposes and with energy recovery

Emissions of NO_X, CO, NMVOC and SO_X from the incineration of waste for energy purposes and from the incineration of waste with energy recovery are reported in the data input cells for "Other fossil fuels" under the relevant subcategories of 1.A.1 and 1.A.2. Explanations for Estimation Method, emission factors, and activity data are all given in the section "A3.1.5 Wastes".

A3.1.1.2. Mobile Combustion (1.A.3: NO_X, CO, NMVOC, and SO_X)

A3.1.1.2.a. Domestic Aviation (1.A.3.a: NOx, CO, and NMVOC)

a) Category Description

This section provides the estimation methods for emissions of precursors (NOx, CO, and NMVOC) from combustion of aviation fuel.

b) Methodological Issues

- ***Estimation Method***

NO_X, CO, and NMVOC emissions from the specified sources were calculated by multiplying

the fuel consumption converted to net calorific value by the default emission factors provides in the *2006 IPCC Guidelines* and the *Revised 1996 IPCC Guidelines.*

- ***Emission factors***

Following table data were used.

Table A 3-1 IPCC default emission factors for civil aviation

Gas	EF [g/MJ(NCV)]
NO_X	0.25 *1
CO	0.12 *2
NMVOC	0.018 *2

Source: *1: *2006 IPCC Guidelines*, Vol. 2; Page 3.64, Table 3.6.5
*2: *Revised 1996 IPCC Guidelines*, Vol. 3; Page 1.90, Table 1-47, Jet and Turboprop Aircraft

- ***Activity data***

Figures for jet fuel consumption (for domestic scheduled flights and others [commuter, sightseeing and charter flights]) converted to net calorific value from data described in the *Statistical Yearbook of Air Transport* (Ministry of Land, Infrastructure, Transport and Tourism) were used.

c) Completeness

For aviation gasoline, emissions of NO_X, CO, and NMVOCs are reported as "NE".

A3.1.1.2.b. Road Transportation (1.A.3.b.) Fuel combustion (NO_X, CO, NMVOC, and SO_X)

a) Description of emission source categories

This section provides the estimation methods for emissions of precursors and other substances (NO_X, CO, NMVOC, and SO_X) from fuel combustion of vehicles.

b) Methodological Issues

1) NO_X, CO, and NMVOC

- ***Estimation Method***

NO_X, CO, and NMVOC emissions from the specified mobile sources were calculated by multiplying the distance traveled per year for each vehicle type per fuel by Japan's country-specific emission factor.

- ***Emission factors***

Emission factors were established from the measured values for each vehicle class per fuel type (Ministry of the Environment). The NMVOC emission factors, however, were calculated by multiplying the emission factor of total hydrocarbon (THC) (surveyed by Ministry of the Environment) by the percentage of NMVOC in the THC emission (surveyed by Ministry of the Environment).

Table A 3-2 NO_X emission factors for automobiles

Fuel	Vehicle type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light vehicle	g-NOx/km	0.230	0.159	0.157	0.079	0.071	0.057	0.045	0.035	0.027	0.020	0.016	0.013	0.011
	Passenger vehicle (including LPG)	g-NOx/km	0.237	0.203	0.199	0.080	0.072	0.059	0.047	0.037	0.028	0.021	0.016	0.013	0.010
	Light cargo truck	g-NOx/km	0.873	0.658	0.375	0.200	0.181	0.154	0.128	0.106	0.089	0.076	0.066	0.059	0.052
	Small cargo truck	g-NOx/km	1.115	0.897	0.478	0.087	0.074	0.056	0.042	0.032	0.025	0.020	0.016	0.013	0.011
	Regular cargo truck	g-NOx/km	1.833	1.093	0.560	0.162	0.165	0.094	0.061	0.043	0.032	0.026	0.022	0.018	0.016
	Bus	g-NOx/km	4.449	3.652	2.438	0.090	0.076	0.063	0.052	0.040	0.034	0.030	0.026	0.025	0.023
	Special-purpose vehicle	g-NOx/km	1.471	0.873	0.429	0.121	0.109	0.078	0.052	0.037	0.029	0.024	0.020	0.017	0.014
Diesel	Passenger vehicle	g-NOx/km	0.636	0.526	0.437	0.448	0.444	0.414	0.384	0.361	0.339	0.312	0.279	0.237	0.197
	Small cargo truck	g-NOx/km	1.326	1.104	1.005	1.009	0.980	0.902	0.829	0.744	0.658	0.580	0.506	0.438	0.384
	Regular cargo truck	g-NOx/km	5.352	4.586	4.334	4.497	4.430	4.235	4.028	3.759	3.422	3.115	2.788	2.462	2.178
	Bus	g-NOx/km	4.226	3.830	3.597	4.070	3.967	3.724	3.502	3.212	2.880	2.615	2.378	2.184	1.979
	Special-purpose vehicle	g-NOx/km	3.377	2.761	2.152	3.626	3.555	3.358	3.164	2.923	2.633	2.381	2.129	1.878	1.651

Source: Ministry of the Environment

Table A 3-3 CO emission factors for automobiles

Fuel	Vehicle Type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light vehicle	g-CO/km	1.749	1.549	1.543	0.971	0.900	0.791	0.692	0.607	0.537	0.483	0.444	0.418	0.401
	Passenger vehicle (including LPG)	g-CO/km	2.325	2.062	2.034	0.936	0.867	0.763	0.667	0.582	0.509	0.452	0.411	0.382	0.363
	Light cargo truck	g-CO/km	10.420	8.540	5.508	2.773	2.490	2.225	2.032	1.887	1.787	1.729	1.691	1.666	1.648
	Small cargo truck	g-CO/km	9.656	10.079	8.309	2.075	1.745	1.330	1.013	0.785	0.607	0.475	0.380	0.310	0.260
	Regular cargo truck	g-CO/km	12.624	10.601	8.950	3.616	3.403	2.155	1.601	1.208	0.941	0.796	0.683	0.571	0.499
	Bus	g-CO/km	26.209	25.079	21.938	2.072	1.815	1.589	1.320	1.140	1.066	0.976	0.928	0.923	0.917
	Special-purpose vehicle	g-CO/km	12.466	10.666	8.924	2.298	2.015	1.528	1.138	0.886	0.746	0.656	0.580	0.497	0.433
Diesel	Passenger vehicle	g-CO/km	0.480	0.432	0.429	0.374	0.370	0.348	0.317	0.288	0.258	0.224	0.192	0.159	0.128
	Small cargo truck	g-CO/km	0.975	0.896	0.808	0.601	0.559	0.483	0.413	0.343	0.284	0.240	0.204	0.175	0.153
	Regular cargo truck	g-CO/km	3.221	2.988	2.440	2.042	1.905	1.670	1.437	1.205	0.995	0.829	0.670	0.533	0.418
	Bus	g-CO/km	2.579	2.534	2.200	2.035	1.877	1.618	1.386	1.131	0.913	0.761	0.638	0.539	0.449
	Special vehicle	g-CO/km	2.109	1.893	1.297	1.601	1.480	1.273	1.075	0.881	0.713	0.592	0.479	0.378	0.293

Source: Ministry of the Environment

Table A 3-4 NMVOC emission factors for automobiles

Fuel	Vehicle Type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	Light Vehicle	g-HC/km	0.128	0.050	0.048	0.043	0.039	0.033	0.027	0.023	0.019	0.017	0.014	0.013	0.012
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.077	0.030	0.029	0.026	0.023	0.020	0.016	0.014	0.012	0.010	0.009	0.008	0.007
	Passenger Vehicle (including LPG)	g-HC/km	0.189	0.112	0.104	0.030	0.028	0.024	0.020	0.017	0.015	0.012	0.011	0.010	0.009
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.113	0.067	0.062	0.018	0.017	0.014	0.012	0.010	0.009	0.007	0.006	0.006	0.005
	Light Cargo Truck	g-HC/km	1.058	0.610	0.274	0.151	0.136	0.115	0.096	0.079	0.066	0.057	0.050	0.044	0.039
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.635	0.366	0.165	0.091	0.082	0.069	0.058	0.048	0.040	0.034	0.030	0.026	0.023
	Small Cargo Truck	g-HC/km	1.188	0.882	0.346	0.068	0.056	0.041	0.030	0.022	0.017	0.013	0.010	0.008	0.006
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.713	0.529	0.208	0.041	0.034	0.025	0.018	0.013	0.010	0.008	0.006	0.005	0.004
	Regular Cargo Truck	g-HC/km	1.658	0.959	0.471	0.103	0.107	0.064	0.043	0.029	0.020	0.016	0.013	0.011	0.009
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.995	0.575	0.283	0.062	0.064	0.039	0.026	0.018	0.012	0.010	0.008	0.006	0.005
	Bus	g-HC/km	3.604	3.164	2.193	0.065	0.051	0.037	0.029	0.023	0.020	0.017	0.015	0.015	0.014
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	2.162	1.899	1.316	0.039	0.031	0.022	0.017	0.014	0.012	0.010	0.009	0.009	0.008
	Special Vehicle	g-HC/km	1.619	0.786	0.317	0.081	0.072	0.050	0.035	0.025	0.020	0.017	0.014	0.012	0.010
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.972	0.472	0.190	0.048	0.043	0.030	0.021	0.015	0.012	0.010	0.009	0.007	0.006
Diesel	Passenger Vehicle	g-HC/km	0.109	0.098	0.097	0.089	0.088	0.084	0.078	0.072	0.066	0.059	0.052	0.044	0.035
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.065	0.059	0.058	0.053	0.053	0.051	0.047	0.043	0.040	0.036	0.031	0.026	0.021
	Small Cargo Truck	g-HC/km	0.389	0.343	0.258	0.206	0.186	0.150	0.119	0.090	0.067	0.050	0.037	0.027	0.020
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.233	0.206	0.155	0.124	0.112	0.090	0.071	0.054	0.040	0.030	0.022	0.016	0.012
	Regular Cargo Truck	g-HC/km	1.634	1.488	1.040	0.753	0.692	0.588	0.488	0.394	0.315	0.254	0.200	0.157	0.123
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.980	0.893	0.624	0.452	0.415	0.353	0.293	0.237	0.189	0.153	0.120	0.094	0.074
	Bus	g-HC/km	1.273	1.255	0.995	0.807	0.729	0.604	0.495	0.381	0.291	0.233	0.189	0.156	0.128
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.764	0.753	0.597	0.484	0.438	0.362	0.297	0.229	0.175	0.140	0.113	0.094	0.077
	Special Vehicle	g-HC/km	1.101	0.965	0.526	0.575	0.521	0.431	0.350	0.276	0.216	0.174	0.138	0.109	0.085
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.661	0.579	0.316	0.345	0.312	0.259	0.210	0.165	0.129	0.105	0.083	0.065	0.051

Top row: THC emission factors;
Middle row: Percentage of NMVOC in the THC emission;
Bottom row: NMVOC emission factors;
Source: Ministry of the Environment

- ***Activity data***

For the activity data, the travel distance per year for each vehicle class by fuel type, estimated for CH_4 and N_2O emissions, are used. (See Chapter 3)

2) SO_X

- ***Estimation Method***

The emissions of SO_X from these sources were calculated by multiplying fuel consumption of each fuel type by Japan's country-specific emission factor.

- ***Emission factor***

Sulfur content (by weight) by fuel type was used.

Table A 3-5 Sulfur content (by weight) by fuel type

Fuel	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Gasoline	%	0.008%	0.008%	0.008%	0.005%	0.005%	0.005%	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%
Diesel	%	0.350%	0.136%	0.050%	0.005%	0.005%	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%	0.001%
LPG	%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%

Source: Gasoline – The Institute of Behavioral Science (by 2004); Upper limits of regulations (2005 onward),
Diesel oil – Petroleum Association of Japan (by 1997); Upper limits of regulations (1998 onward)
LPG – The Institute of Behavioral Science

- ***Activity data***

Activity data, fuel consumption data of weight value, were calculated by multiplying fuel consumptions of each fuel type, reported in in the *General Energy Statistics* (Agency for Natural Resources and Energy), by the specific gravity of each fuel type.

c) Completeness

Emissions of NO_X, CO, NMVOC, and SO_X from natural gas vehicles and motorcycles are reported as "NE".

A3.1.1.2.c. Vehicle (1.A.3.b.) fuel volatilization (excluding motorcycle) (NMVOC)

a) Description of emission source categories

This section provides the estimation methods for emissions of NMVOC caused by fuel volatilization of vehicle. NMVOC is emitted from vehicles which run on gasoline, by volatilization of gasoline component in tank. Fuel evaporative emission is classified into the following three types. Evaporating gas in filling gasoline is included in the calculation of fugitive emissions from fuels at gas station (1.b.2.a.v.).

Table A 3-6 Classification of fuel evaporative gasses

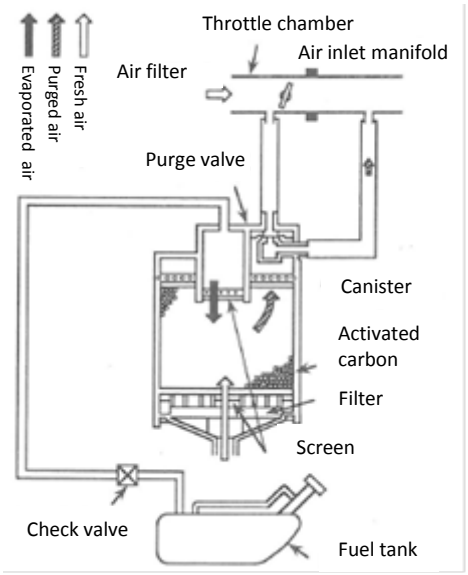
Types	Description
Diurnal Breathing Loss (DBL)	Evaporated gas which is generated when gasoline vapor generated mainly due to the change in temperature during parking is vented to atmosphere after breakthrough[1] from canister[2].
Hot Soak Loss (HSL)	Evaporated gas which is generated from gasoline attached to induction pipe within one hour after shutdown of an engine
Running Loss (RL)	Evaporated gas which is generated when the temperature of gasoline rise during driving and it go beyond the limitation of canister purging[3].

1 "Breakthrough" means going through of absorbing without being absorbed when its amount go beyond the absorption capacity of canister.

2 Canister is absorption equipment in which activated carbon and other substances are included to prevent from generating of evaporated gas in fuel system of gasoline car. Evaporated gas during parking is absorbed by canister; absorbed evaporated gas is delivered to intake manifold during driving, then, absorption capacity of canister recovers.

3 Purge means delivering evaporated gas, together with air, to intake manifold.

Source: the *PRTR Outside Notification Emissions Estimated Data* (Ministry of Economy, Trade and Industry, and Ministry of the Environment, 2012.)



Source: Technology of engine in vehicle for environment, Society of Automotive Engineers of Japan

Figure A 3-1 Structure of fuel tank and canister

b) Methodological issues

Fuel evaporated emissions were estimated by adjusting THC emission data of DBL, HSL, and RL in 2002 by annual number of cars owned and annual travel distance. The emissions in 2002 were provided in "*Development research of new testing methodology for emission gas from vehicle (Special-purpose vehicle)*, Ministry of the Environment, FY2003". This methodology is similar to the *PRTR Outside Notification Emissions Estimated Data*, Ministry of Economy, Trade and Industry, and Ministry of the Environment.

In estimating emissions in RL, PRTR emission data was used after 2003.

It was assumed that THC emissions = NMVOC emissions, since methane is not included in fuel

evaporated gas[2]. Outline of estimation method in each emission source and used data is shown in Table A 3-7.

Table A 3-7 Descriptions for estimating emissions from evaporated gas by mobile fuel combustion

Category	Equation	Data for calculation
DBL	$E_n = \sum_p \sum_q \sum_r (E_{2002} * \frac{N_{n,p,q,r}}{N_{2002,p,q,r}})$ E_n : DBL emissions in FYn [t-NMVOC] $N_{n,p,q,r}$: Number of vehicles owned [unit] in a fiscal year (FY)n in a prefecture *p*, by vehicle type *q*, by status of regulated or not-regulated *r*	E_{2002}: THC emission amount in FY2002 provided in *Development research on new testing methodology for emission gas from vehicle* (Ministry of the Environment, FY2003) *N*: Based on *Monthly report Statistics of AIRIA Number of Motor Vehicle (by prefecture, type of vehicle, sector, and type of fuel)* (Automobile Inspection & Registration Information Association (AIRIA) – published in every March) and *Statistics of AIRIA Number of Motor Vehicle* (AIRIA)
HSL	$E_n = \sum_p \sum_q (E_{2002} * \frac{N_{n,p,q}}{N_{2002,p,q}})$ E_n: DBL emissions in FYn [t-NMVOC] $N_{n,p,q}$: Number of vehicles own [unit] in a fiscal year (FY)n in a prefecture *p*, by status of regulated or not-regulated	E_{2002}: THC emission amount in FY2002 provided in *Development research on new testing methodology for emission gas from vehicle* (Ministry of the Environment, FY2003) *N*: Based on *Monthly report Statistics of AIRIA Number of Motor Vehicle (by prefecture, type of vehicle, sector, and type of fuel)* (AIRIA – published in every March) and *Statistics of AIRIA Number of Motor Vehicle* (AIRIA)
RL	[1990-2002] $E_n = \sum_p \sum_q (E_{2002} * \frac{N_{n,p,q}}{N_{2002,p,q}} * \frac{M_{n,p}}{M_{2002,p}})$ E_n: RL emissions in fiscal year (FY)n [t-NMVOC] $N_{n,p,q}$: Number of vehicles own [unit] in a fiscal year (FY)n in a prefecture *p*, by status of regulated or not-regulated $M_{n,p}$: Travel distance of motorcycle [km] in a fiscal year (FY)n in a prefecture *p* [2003-] PRTR emissions were used.	E_{2002}: THC emission amount in FY2002 provided in *Development research on new testing methodology for emission gas from vehicle* (Ministry of the Environment, FY2003) *N*: Based on *Monthly report Statistics of AIRIA Number of Motor Vehicle* (by prefecture, type of vehicle, sector, and type of fuel) (AIRIA – published in every March) and *Statistics of AIRIA Number of Motor Vehicle* (AIRIA) *M*: Based on *Statistical Monthly book of Motor Vehicle Transport* and *Monthly report Statistics of AIRIA Number of Motor Vehicle (by prefecture, type of vehicle, sector, and type of fuel)* (AIRIA – published in every March)

A3.1.1.2.d. Vehicle (1.A.3.b.) fuel volatilization (motorcycle) (NMVOC)

a) Description of emission source categories

This section provides the estimation methods for emissions of NMVOC by motorcycle caused by fuel volatilization. NMVOC is emitted from motorcycles which run on gasoline, by volatilization of gasoline component in tank due to changes in temperature as described in above section. This section provides estimation method for DBH and HSL as described in the *PRTR*.

b) Methodological issues

Fuel evaporated emissions from motorcycle were estimated by using THC emissions in 2001,

[2] Regarding to concrete volatile element composition, please refer to "*Characteristics of Gasoline Evaporation Composition and VOCs Emission Estimates from Gasoline Passenger Cars at Refueling*, Year book of Tokyo Metropolitan Research Institute for Environmental Protection, 2011".

provided in "*Development research on new testing methodology for emission gas from vehicle (Motorcycle)*, Ministry of the Environment, FY2002", respectively, which were yearly-adjusted by activity data, number of motorcycle owned and travel distance, same methodology with the *PRTR Outside Notification Emissions Estimated Data*, Ministry of Economy, Trade and Industry, and Ministry of the Environment.

Table A 3-8 Descriptions for estimating emissions from evaporated gas by motorcycle fuel combustion

Category	Equation	Data for calculation
DBL	$E_n = \sum_p \sum_q (E_{2001} * \frac{M_{n,p,q}}{M_{2001,p,q}})$ E_n: DBL emissions in FYn [t-NMVOC] $M_{n,p,q}$: travel distance of motorcycle [km] in a fiscal year (FY)n in a prefecture *p*, by vehicle type q,	E_{2001}: THC emission amount in FY2001 estimated based on *Development research on new testing methodology for emission gas from vehicle* (Ministry of the Environment, FY2002) *M*: Based on *Monthly report Statistics of Vehicle*s (Japan Auto- mobile Manufacturers Association, Inc. (JAMA)), *Monthly report Statistics of AIRIA Number of Motor Vehicle* (by prefecture, type of vehicle, sector, and type of fuel) (AIRIA – published in every March) and "*Survey of Motorcycle Market Trends*" (JAMA)
HSL	$E_n = \sum_p \sum_q (E_{2001} * \frac{M_{n,p}}{M_{2001,p}} * R_{n,p})$ E_n: DBL emissions in FYn [t-NMVOC] $M_{n,p,q}$: travel distance of motorcycle [km] in a fiscal year (FY)n by vehicle type *q*, *R*: Use factor adjustment ratio	E_{2001}: THC emission amount in FY2001 estimated based on *Development research on new testing methodology for emission gas from vehicle* (Ministry of the Environment, FY2002) *M*: Based on *Monthly report Statistics of Vehicles* (JAMA), *Monthly report Statistics of AIRIA Number of Motor Vehicle* (by prefecture, type of vehicle, sector, and type of fuel) (AIRIA – published in every March) and "*Survey of Motorcycle Market Trends*" (JAMA) *R*: Estimated by multiplying sales unit for domestic by vehicle type (Web site of JAMA by survival rate by elapsed year (Ministry of the Environment), by use factor by elapsed year in *Estimation method not required to report under the PRTR* (Ministry of the Environment)

A3.1.1.2.e. Railways (1.A.3.c.: NO_X, CO, and NMVOC)

a) Category Description

This section provides the estimation methods for emissions of precursors (NOx, CO, and NMVOC) caused by combustion of diesel railway fuel.

b) Methodological Issues

NO_X, CO, and NMVOC emissions from the specified sources were calculated by multiplying fuel consumption converted to net calorific value by the default emission factors provided in the *Revised 1996 IPCC Guidelines*.

- ***Emission factors***

The default emission factors provided for the "Locomotives" category in the *Revised 1996 IPCC Guidelines* were used.

Table A 3-9 IPCC default emission factors for locomotives

Gas	Emission factor [g/MJ(NCV)]
NO_X	1.8
CO	0.61
NMVOC	0.13

Source: Revised 1996 IPCC Guidelines, Vol. 3; Page 1.89, Table 1-47

- ***Activity data***

The diesel oil consumption by railways in the *General Energy Statistics* (Agency for Natural Resources and Energy) was used.

A3.1.1.2.f. Domestic Navigation (1.A.3.d.: NO_X, CO, NMVOC, and SO_X)

a) Category Description

This section provides the estimation methods for emissions of precursors (NOx, CO, and NMVOC) and SO_X from combustion of marine fuel.

b) Methodological Issues

1) NO_X, CO, and NMVOC

- ***Estimation Method***

NO_X, CO, and NMVOC emissions from the specified sources were calculated by multiplying the fuel consumption converted to net calorific value by the default emission factors provided in the *Revised 1996 IPCC Guidelines*.

- ***Emission factors***

The default emission factors provided in "Ocean-Going Ships" category in the *Revised 1996 IPCC Guidelines* were used.

Table A 3-10 IPCC default emission factors for ocean-going ships

Gas	Emission factor [g/MJ(NCV)]
NO_X	1.8
CO	0.18
NMVOC	0.052

Source: *Revised 1996 IPCC Guidelines*, Vol. 3; Page 1.90, Table 1-48

- ***Activity data***

The marine fuel consumption data converted to net calorific value by fuel type (diesel oil, fuel oil A, fuel oil B, and fuel oil C) from the *General Energy Statistics* (Agency for Natural Resources and Energy) were used. The consumption data were based on the statistical data on marine transport (coastal services [passenger and freight]) in the *Survey on Transport Energy* (Ministry of Land, Infrastructure, Transport and Tourism).

2) SO_X

- ***Estimation Method***

Emissions from the specified sources were calculated by multiplying the fuel consumption by the emission factors.

- ***Emission factors***

Emission factors are calculated by multiplying the specific gravity of each marine fuel by the

sulfur ratio of each fuel by the molecular weight ratio of sulfur dioxide[3] versus sulfur. The sulfur ratio of each fuel is restricted by domestic law and Japanese Industrial Standard. Therefore, the regulation values are used for the sulfur ratio in the estimation.

Table A 3-11 Specific gravity and sulfur ratio of fuel for ocean-going ships

Fuel	Specific Gravity [kg/l]	Sulfur Ratio [% in weight]
Diesel Oil	0.83	0.5 (1990-1991) 0.2 (1992-1997) 0.05 (1998-2004) 0.005 (2005-2006) 0.001 (2007 onward)
Fuel Oil A	0.84	2.0
Fuel Oil B	0.91	3.0
Fuel Oil C	0.93	3.5

Source: Sulfur ratio of diesel oil based on *Petroleum Industry in Japan 2015* (Petroleum Association of Japan)
Sulfur ratio of each fuel oil based on Japanese Industrial Standard K2205
Specific gravity based on *Regulation of Total NO_X Emission Manual*

- ***Activity data***

The marine fuel consumption data of each fuel type (diesel oil, fuel oil A, fuel oil B, and fuel oil C) provided in the *General Energy Statistics* (Agency for Natural Resources and Energy) were used for the activity data. The fuel consumption data were based on the statistical data on marine transport (coastal services [passenger and freight]) in The *Survey on Transport Energy* (Ministry of Land, Infrastructure, Transport and Tourism).

A3.1.1.3. Fugitive emissions from fuel (Oil and natural gas)

A3.1.1.3.a. Oil transport (1.B.2.a.iii): distribution of crude oil

a) Category Description

This section provides the estimation methods for NMVOC emissions which are, as evaporating gas, emitted in losses from breathing and acceptance for storage tank, and loading to lorry tank during distributing domestic crude oil.

b) Methodological Issues

- ***Estimation Method***

Emission amount of NMVOC in this category was estimated by multiplying amount of domestic production of crude oil by emission factor for NMVOC per production volume.

$$E = AD * EF$$

E : NMVOC emissions caused by oil transport [t-NMVOC]
AD : Amount of domestic crude oil production
EF : Emission factor per crude oil production [t-NMVOC/1000kL]

- ***Emission factor***

Emission factors were established by using emission amount from crude oil (evaporating gas)

[3] Most SO_X consists of SO_2. For major sources, SO_2 emissions are estimated.

estimated at *Studies to Develop the National Emissions Inventory for Volatile Organic Compounds* (hereafter, "Studies on VOC Emission Inventories"), Ministry of the Environment. Since emission data indicated in the Studies on VOC Emission Inventories is limited only for FY2000 and FY2005 onward, emission factors in and before FY2004 were evaluated as shown in Table A 3-12, based on evaluated emission by Japan Natural Gas Association.

Table A 3-12 Emission factors for oil transport

FY	The method of establishing of emission factors
FY1990-2004	It was established by dividing estimated total emissions provided by Japan Natural Gas Association by activity data (crude oil output amount)
FY2005-	It was established by dividing estimated total emissions in the Studies on VOC Emission Inventories by activity data (crude oil output amount)

- ***Activity Data***

Crude oil output amount (including condensate) which was provided in *Yearbook of Mineral Resources and Petroleum Products Statistics* was used for activity data.

A3.1.1.3.b. Oil transport (1.B.2.a.iii): Navigation

a) Category Description

NMVOC are emitted in the process of ocean transportation of liquid cargo including gasoline, gas-free operation, and ship loading. This section provides the estimation methods for NMVOC which are emitted from cargo operations by two types of tanker, crude oil tanker and product tanker.

Naphtha is also highly volatile and NMVOC is likely to be emitted. However, naphtha is delivered by confined chemical tanker and prohibited from delivering by product tanker which is not enough treated for electrostatic generation so as to avoid a risk of auto-ignition. Therefore, it is considered that naphtha is not emitted into the air during delivering; so it is not used for estimation. (Although chemical agents are usually delivered by chemical tanker, sometimes they are delivered by product tanker; so all chemical agents are used for estimation so as to avoid from underestimation).

VOC emissions from "crude oil" and "oil products (gasoline)" were included in "1.b.2.a.iv. Refining and storage of oil". Therefore, the emissions were subtracted from total emissions in "1.B.2.a.iv. Refining and storage of oil" and estimated for this category.

VOC emissions from "chemical agent" were also included in "A3.1.2.2.n Chemicals Manufacture" in "2.Industrial Process and Product Use". Therefore, the emissions were subtracted from total emissions in "Chemicals Manufacture" and estimated for this category.

b) Methodological Issues

- ***Estimation Method***

Emission was estimated by multiplying amount of exported or transported "crude oil", "oil products (gasoline)", and "chemical agent" which are reported in tables entitled "Export cargo volume by type of goods, by destination" and "Delivery cargo volume by type of goods, by destination" in *the Statistical Yearbook of Port*, by emission factors.

The following equation is used:

$$E = \sum_i AD_i * EF_i$$

E : Emission amount of NMVOC from evaporation in vessels [t -NMVOC]
AD_i : Traffic volume of cargo i (export volume + transport volume) [t]
EF_i : Emission factor for cargo i [kg-NMVOC/t]
i : Type of cargo (Crude oil, gasoline, chemical agent)

- ***Emission factor***

Emission factors for this source category were established as the following Table A 3-13, based on the *Survey Report on influence of VOC emissions from vessels in FY2005* (Ocean Policy Research Foundation, March 2006).

Table A 3-13 Emission factors for evaporation from vessels

Activity Data		Emission factors [kg-NMVOC/t]
Crude oil	With vapor recovery (Only in Port of Kiire for FY2007 onward)	0.03
	No vapor recovery	0.14
Gasoline	During loading	0.12
	During gas-freeing	0.14
Chemical Agent	Benzene	0.011
	Methanol	0.006
	Toluene	0.004
	Dichloroethane	0.016
	Acetone	0.023

(Source) *Survey Report on influence of VOC emissions from vessels in FY2005* (Ocean Policy Research Foundation, March 2006)

- ***Activity Data***

Based on tables entitled “Export cargo volume by type of goods, by destination” and “Delivery cargo volume by type of goods, by destination” in the *Statistical yearbook of port* (Ministry of Land, Infrastructure, Transport and Tourism), following methods in the Table A 3-14 were used for activity data for this source category.

Table A 3-14 Activity Data for NMVOC emissions from vessels

Activity Data	Description
Crude oil	The volume of export and transport of crude oil was used.
Gasoline	Estimated by multiplying the volume of export and transport of crude petroleum products by the percentage of gasoline in volume of domestic sales and export of petroleum products provided in the *Yearbook of mineral resources and petroleum products statistics.*
Chemical agent	Estimated by multiplying the volume of export and transport of chemical agent by the percentage of NMVOC in chemical agent. The percentage of actual export amount of five chemical agents (Benzene, methanol, toluene, dichloroethane, and acetone), probable emission source of NMVOC, provided in *Report on estimation of improvement of air environment* (Ocean Policy Research Foundation, 2003), was adopted for the percentage of NMVOC in chemical agent.

*Each activity data was based on calendar year (CY); therefore, CY-based-activity data was converted into FY-based data, by combining 75% data from corresponding FY and 25% data from the subsequent FY.

A3.1.1.3.c. Refining and storage of oil (1.B.2.a.iv): Fugitive emissions from oil refinery

a) Category Description

This section provides the estimation methods for NMVOC emissions from fugitive emissions in the process of refining crude oil and producing oil products.

b) Methodological Issues

- ***Estimation Method***

Emissions were estimated by multiplying BPSD (Barrel per Stream Day), production amount per 1 steam day on crude oil distillation unit at normal pressures, by steam days per year by emission factor. Steam days per year were estimated by multiplying days per year, (365 days, but 366 days in leap years) by annual operating rate[4].

NMVOC emissions from fugitive emissions in this category were estimated by using the following equation.

$$E = AD * D * R * EF$$

E	: NMVOC emissions from fugitive emissions in refinery [g-NMVOC/year]
AD	: Fugitive Barrel per Stream Day [BPSD]
D	: Number of working days in a year (365 days, but 366 days in leap years)
R	: Annual operating rate [%]
EF	: Emission factor [g-NMVOC/BPSD]

- ***Emission factors***

Emission factor for this category was established at 5.675 [kg/day/10^5BPSD] which was provided in the *Business Report on Grid Database on Atmospheric Pollutants Emissions, 2000* by The Institute of Behavioral Sciences, in accordance with the Studies on VOC Emission Inventories.

- ***Activity Data***

In accordance with the Studies on VOC Emission Inventories, the capacity of oil refineries (BPSD: Barrels per Stream Day) by *Sekiyu Shiryô* (Sekiyu Tsushin) was used for activity data. Stream days in a year were calculated by multiplying 365 days (366 days for FY1991, 1995, 2003, 2007, 2001: leap years) by annual operating ratio of the instrument which was provided by *Sekiyu Shiryô* (Sekiyu Tsushin) (=annual processing amount [bbl/year]÷annual capacity[bbl/year].

A3.1.1.3.d. Refining and storage of oil (1.B.2.a.iv) Production of lubricant oil

a) Category Description

This section provides the estimation methods for NMVOC emissions from fugitive emissions in the process of dewaxing and deasphalting during production of lubricants.

[4] Processed amount [bbl/year]/Processed capacity [bbl/year]

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from the specified sources were calculated by multiplying gross sales amount to consumers by Japan's country-specific emission factors for toluene and methyl ethyl ketone.

- ***Emission factor***

Based on measurements in Japan, emission factors were established for toluene and methyl ethyl ketone.

Table A 3-15 Toluene and methyl ethyl ketone emission factors in lubricant oil production

Gas	Emission factor [g/kl]
Toluene	333.2
Methyl ethyl ketone	415.5

Source: *Basic Study on HC Sources* (Institute of Behavioral Science, 1987)

- ***Activity data***

Figures for gross sales amount to consumers, provided in the *Yearbook of Mineral Resources and Petroleum Products Statistics* (Ministry of Economy, Trade and Industry), were used for the calculation of activity data.

A3.1.1.3.e. Refining and storage of oil (1.B.2.a.iv): fugitive emissions from storage/shipping facilities

a) Category Description

NMVOC are emitted, with accompanying fuel-evaporated fugitive gasses, by storage and shipping of fuel (e.g., gasoline, crude oil, and naphtha) in crude oil transshipment stations, refineries, and oil tank facilities.

NMVOC emissions from storage facilities include losses from breathing and acceptance for fixed-roof type tank and losses shipping losses from floating-roof type storage tanks at refineries, and from shipping facilities include from shipping losses in loading crude oil or oil products to tanker, tank car, or tank lorry.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from storage and shipping of fuel in crude oil transshipment stations, refineries and oil tank facilities were estimated by using the following equation.

$$E = AD * EF$$

E : Fugitive NMVOC emissions at fuel storage and shipping facilities [g-NMVOC]
AD : Amount of refined crude oil, NGL [PJ]
EF : Emission factor per amount of refined crude oil, NGL [g-NMVOC/PJ]

The above-estimated NMVOC emissions include emissions during loading "crude oil" and "oil

products (gasoline)" to tankers, which is included in "1.B.2.a.iii Oil transport"; therefore, these emissions are subtracted from this category.

- ***Emission factors***

The emission amount in fuel storage and shipping in crude oil transshipment stations, refineries, and oil tank facilities which was estimated for the Studies on VOC Emission Inventories , and the following activity data (the refined amount of crude oil and NGL (in net calorific value (NCV) equivalent)) were applied for establishing emission factors for this category. The emission amount provided in the Studies on VOC Emission Inventories are limited for FY2000 and from FY2005 onward; therefore, emission factors for each FY were established as indicated in the following Table A 3-16.

Any relevant information for FY1990-1999 is not available since any measures based on voluntary action plan on environment had not been implemented yet during the period. Therefore, emission factors for FY2000 were adopted for these period.

For FY2001-2003, since member companies of Petroleum Association of Japan had been continuously implemented voluntary measures for reducing emissions, under the assumption of linearly lowering of emissions factors, emission factors were established by being interpolated with the value of FY2000-2004.

Table A 3-16 Emission factor in fuel storage and shipping in crude oil transshipment stations, refineries, and oil tank facilities

Fiscal Year (FY)	The method of establishing emission factors
1990-1999	Emission factors for FY2000 were applied for these period
2000	Established by dividing emissions provided in the Studies on VOC Emission Inventories, by activity data (the refined amount of crude oil and NGL (in NCV equivalent))
2001-2003	Calculated by interpolating the figure in FY2000 and FY2004.
2004	Established by dividing emissions reported in voluntary action plan by activity data (the refined amount of crude oil and NGL (in NCV equivalent)) Petroleum Association of Japan.
2005-	Established by dividing emissions provided in the Studies on VOC Emission Inventories, by activity data (the refined amount of crude oil and NGL (in NCV equivalent))

- ***Activity Data***

The refined amount of crude oil and NGL (in NCV equivalent) provided in *General Energy Statistics* by Agency for Natural Resources and Energy was used for activity data.

A3.1.1.3.f. NMVOC fugitive emissions from gas stations (1.B.a.v)

a) Category Description

NMVOCs were emitted by evaporation from underground gasoline storage tank (loss from acceptance) or by filling gasoline in cars (loss from filling gasoline).

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions in this category were estimated by multiplying sales volume of gasoline by

emission factors per sales volume of gasoline (loss from acceptance, loss from filling gasoline). For the estimation, the emission factors which corresponds to the average temperature of each prefecture were adopted, taking into consideration influence the emissions by changes in temperature.

$$E = \sum_i \left(AD_i * EF_i \right)$$

E : NMVOC fugitive emission in gas filling station [kg-NMVOC]
AD_i : Sales amount of gasoline in prefecture i [kL]
EF_i : Emission factor per sales amount of gasoline in prefecture i (loss from acceptance, loss from filling gas) [kg-NMVOC/kL]

- ***Emission factors***

Emission factors were established, taking into consideration the average temperature by prefecture, according to the following equation which was based on the *Study on the total system for prevention of HC-Vapor in petroleum industries* (Agency for Natural Resources and Energy, 1975).

The average yearly temperature in each prefectural capital in each FY provided *Weather statistics information* by Japan Meteorological Agency was used for calculation.

➢ ***Equation for emission factor for loss from acceptance***

$$EF_i = (0.46 * T_i + 13.92) / 21$$

EF: Emission factor for loss from acceptance in a city i [kg-NMVOC/kL]
T_i : An average of yearly temperature in a city i [degree C]

➢ ***Equation for emission factor for loss from filling oil***

$$EF_i = (0.97 * T_i + 11.12) / 21$$

EF: Emission factor for loss from filling oil [kg-NMVOC/kL]
T_i : An average of yearly temperature in a city i [degree C]

It was found that an emission factor based on the approximate formula was not so different from an emission factor provided in actual measurement research by Yokota (2012) (1.41g/L for premium gasoline, 1.44g/l for regular gasoline by Yokota (2012): 1.44g/L by Agency for Natural Resources and Energy (1975) (average value at 9 degrees C and 30 degrees C).

For eight prefectures (Saitama, Chiba, Tokyo, Kanagawa, Fukui, Yamanashi, Aichi, and Osaka) which were required to install vapor recovery instrument for acceptance, following the Studies on VOC Emission Inventories, emission factors for losses from acceptance were established by multiplying the established emission factor by 0.15, taking into consideration the emission reduction by vapor recovery instrument.

- ***Activity Data***

Sales volume of gasoline by prefecture provided in the *Yearbook of Mineral Resources and*

Petroleum Products Statistics by Ministry of Economy, Trade and Industry (*Sekiyu Shiryo* by Sekiyu Tsushin for 2013 onward) were used for activity data.

A3.1.1.3.g. Processing of natural gas (1.B.2.b.iii)

a) Category Description

In the process from production to distribution of natural gas, NMVOC originated from natural gas treatment are emitted by vapor from removal device of fluid or impurities (e.g., carbon dioxide gas) contained in natural gas, or, by being released into the air in construction of pipeline relocation.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions by production and treatment of natural gas were estimated by multiplying domestic production volume of natural gas by NMVOC emission factor per production volume.

$$E = AD * EF$$

E : NMVOC emission amount by production and treatment of natural gas [t-NMVOC]
AD : Production volume of natural gas [million m^3]
EF : Emission factor per production volume of natural gas [t-NMVOC/million m^3]

- ***Emission factor***

Emission factors were established using natural gas emission amount which was estimated at the Studies on VOC Emission Inventories by Ministry of the Environment (based on the reported figures of voluntary action plan by Japan Natural Gas Association) and later-indicated activity data (domestic production volume of natural gas). Emission factors in and before FY2004 were, same as shown in "Oil transport (1.B.2.a.iii)", established as the following Table A 3-17, using the emissions provided by Japan Natural Gas Association, since indicated emission amount in the Studies on VOC Emission Inventories is limited only for FY2000 and from FY2005 onward.

Table A 3-17 The method of establishing emission factors for production and treatment of natural gas

Fiscal Year (FY)	The method of establishing emission factors
1990-2004	Established by dividing emissions provided by Japan Natural Gas Association, by activity data (production amount of natural gas) for 1990-2004.
FY2005-	Established by dividing emissions provided by Japan Natural Gas Association, by activity data (production amount of natural gas) from FY2005 onward.

- ***Activity data***

Domestic production volume of natural gas provided by *Yearbook of Mineral Resources and Petroleum Products Statistics* (Ministry of Economy, Trade and Industry) was used for activity data.

- ***Completeness***

The emissions from this source include the emissions from "transmission and storage of natural gas (1.B.2.b.iv)" and "venting (gas) (1.B.2.c.V.ii)".

A3.1.1.3.h. Natural gas distribution (1.B.2.b.v): Town gas production

a) Category Description

NMVOC are emitted by fugitive emissions from naphtha tank in the process of town gas production. In Japan, no emission activities in this category has been made since FY2006 because naphtha has not been used for town gas production due to the completion of shifting raw materials of town gas from naphtha to LNG in order to raise the calorific value in FY2005.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from naphtha tank in town gas production were estimated by multiplying consumption amount of gasoline used as raw material for town gas production by NMVOC emission factor per consumption amount. The emissions in this category from FY2006 onward are reported as "NO" since no emission activity has been made during these period.

$$E = AD * EF$$

E : NMVOC emission amount in town gas production [t-NMVOC]
AD : Consumption amount of gasoline used as material for town gas raw production [kL]
EF : NMVOC emission factor per consumption amount [t-NMVOC/ kL]

- ***Emission factor***

Emission factors for town gas production were established based on emission amount from "gas production facilities" (estimated based on *Report on Voluntary Action Plan by The Japan Gas Association*) provided in the Studies on VOC Emission Inventories by Ministry of the Environment and consumption amount of crude gasoline for town gas production.

Table A 3-18 The method of establishing emission factors for town gas production

FY	The method of establishing emission factors
FY1990-1999	Emission factors for FY2000 were used for all fiscal years
FY2000	Established by dividing emission amount in FY2000 provided in the Studies on VOC Emission Inventories by activity data (consumption amount of crude gasoline)
FY2001-2003	Established by interpolating, using the emission factors for FY2000 and FY2004
FY2004	Established by dividing emission amount in FY2004 provided in the Voluntary Action Plan by Activity Data (consumption amount of crude gasoline)
FY2005	Established by dividing emission amount provided in the Studies on VOC Emission Inventories in FY2005 by activity data (consumption amount of crude gasoline for production of town gas)

- ***Activity data***

The consumption amount of gasoline used as raw material for town gas production provided in the *Gas Industry Yearbook* of the Agency for Natural Resources and Energy was used for activity data.

A3.1.2 Industrial Processes and Product Use (IPPU)

A3.1.2.1. Mineral Products, Chemical Industry, Metal Production, and Other Production (2.A., 2.B., 2.C., 2.D.,: NO_X, SO_X)

a) Category Description

This section provides the estimation methods for emissions of precursors and other substances (NO_X, and SO_X) from the process to produce mineral products, chemical industry, metal production and other production.

b) Methodological Issues

- ***Estimation Method***

NO_X and SO_X emissions from the specified sources, not included in the following facilities or industry sectors, were estimated by isolating the emissions of the IPPU sector from the data in the *General Survey of the Emissions of Air Pollutants* by Ministry of the Environment.

Facility: [0101– 0103: Boilers]; [0601– 0618: Metal rolling furnaces, metal furnaces, and metal forge furnaces]; [1101–1106: Drying ovens]; [1301–1304: Waste incinerators]; [2901–3202: Gas turbines, diesel engines, gas engines, and gasoline engines]

Industry sector: [A–D: Accommodation/eating establishments, health care/educational and academic institutions, pubic bathhouses, laundry services]; [F–L: Agriculture/fisheries, mining, construction, electricity, gas, heat distribution, building heating/other operations]

- ***NO_X***

If raw material falls under either [44: Metallurgical coal] or [45: Metallurgical coke], the following equation is used:

Calculation of NO_X emissions from metallurgical coal or coke (for IPPU sector)

NO_X emissions from metallurgical coal or coke [t-NO_X]
= NO_X emission factor by material [t- NO_X /kcal] × energy consumed by material [kcal]
× (1 – Nitrogen removal rate [%])

If raw material falls under either [41: Iron/ironstone] or [46: Other], the following equation is used:

Calculation of NO_X emissions from iron/ironstone or other material (for IPPU sector)

NO_X emissions from iron/iron ore or other material [t-NO_X]
= Nitrogen content in each material [t-NO_X] × (1 – Nitrogen removal rate [%])

If, however, the emissions from the IPPU sector calculated by the above equations exceed the emission amount listed in the *General Survey of the Emissions of Air Pollutants*, the total emissions listed in the Survey are considered to be the emissions from the IPPU sector. Materials listed in the categories [42: Sulfide minerals] and [43: Non-ferrous metal ores] are

excluded from the calculation due to the lack of data.

➢ ***SO_X***

Emissions from the IPPU sector is calculated from the consumption and sulfur contents of the materials in categories from [41: Iron/ironstone] to [46: Other materials]. Energy sector emissions are estimated by subtracting IPPU sector emissions from the emissions listed in the *General Survey of the Emissions of Air Pollutants* to determine SO_X emissions.

Calculation of SO_X emissions (in the IPPU sector)

SO_X emissions [t-SO_X]
= Sulfur content in each material [t-SO_X] × (1 – desulfurization rate [%])

● ***Emission factor***

➢ ***NO_X emission factors for metallurgical coal and coke***

NO_X emission factors for the materials used in calculation of NO_X emissions from metallurgical coal and coke (in the IPPU sector) were established for each facility and material type based on the *General Survey of the Emissions of Air Pollutants*.

➢ ***Nitrogen removal rate***

The nitrogen removal rate was calculated by the following equation:

Calculation of nitrogen removal rate

Nitrogen removal rate [%]
= Nitrogen removal efficiency [%] × (Hours of operation of nitrogen removal unit [h/yr]
/ Hours of operation of furnace [h/yr]) × (Processing capacity of nitrogen removal unit [m^3/yr]
/ Maximum exhaust gas emission [m^3/yr])

The *General Survey of the Emissions of Air Pollutants* data was used for all items.
Nitrogen removal efficiency = (NO_X volume before treatment – NO_X volume after treatment) / volume of smoke and soot

➢ ***Desulfurization rate***

The desulfurization rate was calculated by the following equation:

Calculation of desulfurization rate

Desulfurization rate [%]
= Desulfurization efficiency [%] × (Hours operation of desulfurization unit [h/yr]
/ Hours operation of furnace [h/yr]) × (Processing capacity of desulfurization unit [m^3/yr]
/ Maximum exhaust gas emission [m^3/yr])

The *General Survey of the Emissions of Air Pollutants* data were used for all items.
Desulfurization efficiency = (SO_X volume before treatment – SO_X volume after treatment) / volume of smoke and soot

● ***Activity data***

➢ ***Energy consumption of metallurgical coal or coke***

The activity data was calculated by multiplying the consumption of materials (under [44: Metallurgical coal] and [45: Metallurgical coke]) provided in the *General Survey of the Emissions of Air Pollutants* by gross calorific value.

➢ ***Nitrogen content of iron/ironstone and other materials***

The activity data was calculated by multiplying the weighted average of nitrogen content, calculated from the nitrogen content and consumption of the materials (under [41: Iron/ironstone] and [46:Other raw materials]) provided in the *General Survey of the Emissions of Air Pollutants*, by the consumption amount of the material.

➢ ***Sulfur content of various materials***

The activity data was calculated by multiplying the weighted average of sulfur content, calculated on the basis of sulfur content and consumption of the material (under [41: Iron/ironstone] through [46: Other materials]) provided in the *General Survey of the Emissions of Air Pollutants*, by the consumption amount of the material.

A3.1.2.2. Non-energy products from fuels and solvent use (2.D.3.) (NMVOC)

A3.1.2.2.a. Use of paint

a) Category Description

NMVOC are emitted by paint containing solvent and diluent, in the process of using paint including painting industrial products or buildings[5].

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from use of paint were estimated by multiplying sales amount of paint by NMVOC emission factor per sales amount of paint.

$$E = AD * EF$$

E : NMVOC emissions from use of paint emission [1000t -NMVOC]
AD : Sales amount of paint [1000t]
EF : Emission factor per sales amount of paint [t-NMVOC/t]

- ***Emission factor***

The annual survey on VOC emissions from use of paint by Japan Paint Manufacturers Association has been conducted since FY2000 (excluding FY2002) NMVOC emissions per sales amount of paint which calculated by dividing emissions provided in the survey by sales amount of paints are used for emission factor for use of paint.

Due to the lack of weight data for establishing emission factors for FY1999 and before, emission factors for these periods were established by extrapolating based on the trend during FY2000-FY2010: a reducing trend was obvious during FY2000-FY2010, and FY2010 was the target year of voluntary action plan based on Air Pollution Control Act; it was assumed, similarly, during FY1990-1999 emissions might tend to reduce because of possible shift to aqueous paint and installation of VOC processing instruments. (Please refer to Table A 3-19)

[5] The emission in the process of manufacturing were estimated in "A3.1.2.2.n Chemicals Manufacture"

Table A 3-19 The method of establishing NMVOC emission factors for use of paint

Fiscal Year (FY)	The method of establishing emission factors
1990-1999	Established by extrapolating based on a trend in FY2000-2010
2000-2001	Established by dividing VOC emissions in FY2000 for use of paints (by Japan Paint Manufacturers Association) by the sales amount of paint
2002	Established by interpolating based on emission factor which was calculated by dividing emissions in FY2001 and FY2003 by activity data in FY2001 and FY2003
2003-	Established by dividing VOC emissions for paint in FY2003 and thereafter (Japan Paint Manufacturers Association) by sales amount of paint.

- ***Activity Data***

The sales amount of paint provided in *Yearbook of current production statistics chemical industry*, by Ministry of Economy, Trade and Industry was used for activity data.

A3.1.2.2.b. Dry-cleaning

a) Category Description

NMVOC are emitted from dry cleaning laundry equipment by using solvent for dry cleaning of clothes.

b) Methodological Issues

NMVOC emissions from dry-cleaning were estimated by deducting "weight as waste" (including residual weights in cartridge and distilling sludge) from "used weight of dry cleaning solvent"

$$E = AD - A - B$$

E : NMVOC emissions from use of dry-cleaning solvent [t -NMVOC]
AD : Used weight of dry-cleaning solvent (Tetrachloroethylene, Industrial gasoline No.5) [t]
A : Absorbed residual solvent in cartridge filter to be disposed as waste (Transferred weight of absorption solution in changing cartridge filter) [t]
B : Residual solvent containing distilling sludge to be disposed as waste (Transferred weight of residual solvent in distilling sludge) [t]

- ***Emission factor***

No emission factors were established, as all the solvents used in dry cleaning were assumed to be discharged into the atmosphere.

- ***Activity data***

1) Used weight of dry-cleaning solvent

Used weight of dry-cleaning solvent (tetrachloroethylene, Industrial gasoline No.5) was estimated according to the Table A 3-20 and Table A 3-21, following data in the Studies on VOC Emission Inventories.

Table A 3-20 The method of estimating activity data for dry-cleaning solvent (Tetrachloroethylene)

Fiscal year (FY)	The method of estimating activity data
1990, 1991	Estimated by multiplying total consumption weight of the solvent in FY1990 and FY1991 by the percentage for dry-cleaning in FY1992 which was calculated based on "Demand by end-usage" by Japan Association for Hygiene of Chlorinated Solvents, since the data for FY1990 and 1991 was not available.
1992	Used weight of tetrachloroethylene provided in "Demand by end-usage" by Japan Association for Hygiene of Chlorinated Solvents was used for activity data
1993, 1994	Estimated by interpolating the value provided in "Demand by end-usage" by Japan Association for Hygiene of Chlorinated Solvents for FY1992 and FY1995.
1995-	Used weight of tetrachloroethylene provided in "Demand by end-usage" by Japan Association for Hygiene of Chlorinated Solvents was used for activity data

Table A 3-21 The method of estimating activity data for dry-cleaning solvent (Industrial gasoline No.5)

Fiscal year (FY)	The method of estimating activity data
1990, 1991	Estimated by multiplying used weight of industrial gasoline No.5 in FY1992 by installation ratio of laundry machine which use petroleum dissolution in FY1992, provided in *The survey on usage of dry-cleaning solvent* by Ministry of Health, Labour and Welfare
1992-1999	Estimated by multiplying shipping weight of petroleum dry cleaning solvent in FY2000, provided in *Shipping weight of solvent* by Japan cleaning solvent association, by used weight of industrial gasoline no.5 in FY2000
2000	Used the result of the survey on the shipping weight of dry cleaning solvent by petroleum solvent manufacturer, indicated in the Studies on VOC Emission Inventories.
2001-2004	Estimated by interpolating the values in FY2000 and FY2005
2005-	Used the result of the survey on the shipping weight of dry cleaning solvent by petroleum solvent manufacturer, indicated in VOC emissions inventories.

2) Deducting weight as waste

Weight of waste transfer (including residual weights in cartridge and distilling sludge) was estimated by equations in the following Table A 3-22, in accordance with the method of the Studies on VOC Emission Inventories by Ministry of the Environment; the weight was deducted from the used weight of dry-cleaning solvent. Values used for the Studies on VOC Emission Inventories based on hearing and other survey were used as parameters for estimation.

As for installed units of dry cleaning laundry, values provided in *Survey on usage and management of solvent for dry-cleaning* by Ministry of Health, Labour and Welfare were used. However, the survey has been conducted biyearly after FY2001; therefore, the same values in the previous fiscal year were used for years which the survey was not conducted.

Table A 3-22 The method of estimation for weight of waste transfer in dry-cleaning solvent

Type of waste	The method of estimation for weight of waste transfer in dry-cleaning solvent
Transfer weight of absorbed solvent in changing cartridge filter	Since 2L solvent per 1kg of laundries is absorbed in cartridge on average, the estimated annual weight is calculated according to the following formula. Absorbed weight in cartridge (kg/year) = Absorbed VOC weight (L/time/kg) in each changing of cartridge per 1kg of loading weight by washer x Gravity (kg/L) x Annual average of operating washer (time/year) / Average washer times per changing cartridge filter (time/time) x Number of unit of installed laundry (unit)
Transfer weight of residual solvent in distilling sludge	Transferred weight of solvent in distilling was estimated according to the following formula. Contained residual solvent in distilling sludge (kg/yeas) = Standard load of washer (kg/unit) x Annual Average of operating times of washer (time/year) x Factors by type of filter (kg/kg) x Unit of installation of laundry (unit) x Installation rate of distilling (%)

Source : the Studies on VOC Emission Inventories (Ministry of the Environment)

A3.1.2.2.c. Metallic cleaning

a) Category Description

NMVOC are emitted by cleaning of metallic components by industrial cleaner in the process of manufacturing electrical/electronic products or metallic components.

b) Methodological Issues

- ***Estimation Method***

1) Chlorine Cleaner

NMVOC emissions from the use of chlorine cleaner were estimated by multiplying the used amount of chlorine cleaner by emission rate. Since some chlorine cleaner are recycled, the emissions were adjusted.

$$E = AD * R * EF$$

E : NMVOC emissions from the use of chlorine cleaner [1000t -NMVOC]
AD : Sales amount of chlorine cleaner [1000t]
R : Adjustment rate for recycle[6] (x 1.1)
EF : Atmospheric emission rate by use of chlorine cleaner [%]

2) Non-chlorine cleaners

NMVOC emissions by the use of semi-aquatic, hydrocarbon system, or alcohol system cleaner were estimated by multiplying the used weight of cleaner by atmospheric emission rate.

$$E = AD * EF$$

E : NMVOC emissions by the use of semi-aquatic, hydrocarbon system, or alcohol system cleaner [1000t -NMVOC]

[6] JICC researched at Japan Solvent Recycling Industry Association, approximately 10 % of sales amount of chlorine cleaner recycled and resupplied by recycle companies. (*Studies to develop the national emissions inventory for volatile organic compounds (VOC), FY 2011*, Ministry of the Environment)

AD : Used weight of semi-aquatic, hydrocarbon system, or alcohol system cleaner [1000t]
EF : Atmospheric emission rate from the use of semi-aquatic, hydrocarbon system, or alcohol system cleaner [%]

- ***Emission factors***

Emission factors provided in the Studies on VOC Emission Inventories by Ministry of the Environment, as shown in the Table A 3-23, were used for chlorine cleaner and non-chlorine cleaners.

Table A 3-23 NMVOC emission factors for use of each type of cleaner

Types of cleaner	Atmospheric emission rate	Source
Chlorine cleaner	75%	Commission report on manual for promoting voluntary approach for emission control of VOC in FY2005 by Japan Industrial Conference on Cleaning (JICC)
Semi-aquatic cleaner	0.4%	The result of the survey by JICC
Hydrocarbon system cleaner	31.3%	
Alcohol system cleaner	60% (45% for FY2010 and thereafter)	
Fluorinated cleaner	84%	
Other types cleaner	75%	

- ***Activity Data***

1) Chlorine cleaner

Activity data for chlorine cleaner was established as shown in the following Table A 3-24 and Table A 3-25, based on the Studies on VOC Emission Inventories by Ministry of the Environment and data provided by Japan Association for Hygiene of Chlorinated Solvents. According to the Studies on VOC Emission Inventories, among the sales amount of chlorine cleaner, about 10% of them are recycled and resupplied; therefore, taking into consideration recycled weight, adjusting by multiplying estimated used amount by 110%, the after-adjustment –values were adopted for activity data.

Table A 3-24 Activity data for the use of Chlorine cleaner
(Dichloromethane, Trichloroethylene, tetrachloroethylene)

Fiscal Year (FY)	Activity data
1990-1994	Estimated by multiplying total consumption amount in each fiscal year by the proportion of metallic cleaner in FY1995 (calculated based on “Demand by use” by Japan Association for Hygiene of Chlorinated Solvents) since data was not available for FY1990-1994.
1995-	The sales amount of dichloromethane, trichloroethylene, and tetrachloroethylene for metallic cleaning provided in “Demand by use” by Japan Association for Hygiene of Chlorinated Solvents was adopted for activity data.

Table A 3-25 Activity data for the use of Chlorine cleaner (Other types of Chlorine cleaner)

Fiscal Year (FY)	Activity data
1990-1999	Estimated by multiplying total consumption amount for three major chlorine cleaners for 2000 by the ratio in FY1990-1999 to the values in FY2000
2000	The sales amount provided in the Studies on VOC Emission Inventories was used for activity data. (The result of research by Japan Industrial Conference on Cleaning)
2001-2004	Estimated by interpolating the activity data for FY2000 and FY2005
2005-	The sales amount provided in the Studies on VOC Emission Inventories was used for activity data. (The result of research by Japan Industrial Conference on Cleaning)

2) Non-chlorine cleaner

Activity data for non-chlorine cleaner (semi-aquatic, hydrocarbon system, or alcohol system cleaner) was established as shown in the following Table A 3-26 based on the information provided in the Studies on VOC Emission Inventories by Ministry of the Environment.

Table A 3-26 Activity data for non-chlorine cleanser

Fiscal year (FY)	Activity data
FY1990-1999	Total amount of raw material by type of cleanser was calculated by multiplying the proportion by type of manufacturer provided in the Studies on VOC Emission Inventories (Table A 3-27) by corresponding the used weight of raw material; then, the activity data (the used weight) for each year was estimated by multiplying the calculated total weight by the ratio from FY2000.
FY2000	Used weight of each type of cleaner in the Studies on VOC Emission Inventories was adopted for activity data.
FY2001-2004	Estimated by interpolating the activity data for FY2000 and FY2005.
FY2005-	Used weight of each type of cleaner in the Studies on VOC Emission Inventories was adopted for activity data. As for values in the Studies on VOC Emission Inventories, the result of a survey (sampling) was used after an adjustment. The survey has not been conducting every year. Therefore, for years when the survey was not conducted, data has been supplemented by using interpolated method.

Table A 3-27 The proportion by type of manufacturer in VOC emissions from non-chlorine cleanser

	Manufacture	n-Methyl-pyrrolidone admixture	Glycol ether admixture	n-Paraffin cleaner	Isoparaffin cleaner	Naphthene cleaner	Other carbon hydride cleaner	Isopropyl alcohol cleaner	Other alcohol cleaner	HFC cleaner	Other fluorine cleaner	Bromine cleane	Other cleaner
19	Plastic Products			3%	6%	4%			12%				
23	Iron and Steel			3%	0.1%	5%				1%	2%		
24	Non-Ferrous Metals and Products			16%	0.05%	7%				1%	2%		
25	Fabricated Metal Products		2%	17%	30%	26%	8%					4%	
26	Machinery			11%	8%	15%	11%			1%	2%		
28	Communications		19%					1%					
29	Electric device	70%	49%	17%	15%	7%	13%	25%	28%	28%	38%	30%	100%
30	Transport		2%	16%	26%	36%	10%		12%	7%	19%	18%	
31	Precision apparatus	30%	18%	17%	15%		18%	74%	46%	61%	37%	48%	
32	Other		10%	0.1%		1%	41%		3%				
	Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: The *Survey Report on VOC emission inventories*, Ministry of the Environment, FY2012

A3.1.2.2.d. Thinner for cleaning manufacturing equipments

a) Category Description

NMVOC are emitted by the use of thinner for cleaning manufacturing equipment.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from thinner for painting was estimating by multiplying the same volume of thinner excluding one for painting by emission factor for NMVOC per sales amount.

$$E = AD * EF$$

E : NMVOC emissions by the use of cleaning thinner [t-NMVOC]
AD: The sales volume of thinner excluding one for painting [kL]
EF : Emission factor per sales amount of cleaning thinner [t-NMVOC/ kL]

- ***Emission factors***

Emission factor was established by using the emissions from "thinner for cleaning manufacturing equipment" provided in the Studies on VOC Emission Inventories by Ministry of the Environment and later-described activity data.

Although the trend of emission factor is decreased after FY2000, emission factor for FY2000 is applied for each fiscal year during FY1990 to FY1999, due to no quantitative data for estimating emission factors in related organization and the difficulties for implementation of measurement for drastic reduction of emissions from thinner cleaning (Table A 3-28).

Table A 3-28 The method of establishing of emission factors of cleaning thinner for manufacturing equipment

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was applied for all fiscal years
2000	Estimated by dividing emissions in FY2000 provided in the Studies on VOC Emission Inventories by activity data.
2001-2004	Estimated by interpolating the activity data for FY2000 and FY2005
2005-	Estimated by dividing emissions in FY2005 and thereafter provided in the Studies on VOC Emission Inventories by activity data.

- ***Activity data***

The sales volume of thinner in FY1990 and thereafter was estimated by deducting consumption amount of diluent thinner provided in *Summary of estimation for current status of VOC emissions from painting* (Japan Paint Manufacturers Association) from the sales volume of thinner provided in *Yearbook of chemical industry* (Ministry of Economy, Trade and Industry).

Since data on the consumption amount of diluent thinner in and before FY2004 was unidentified, it was estimated (Table A 3-29).

Table A 3-29 The method of estimating activity data for the use of diluent thinner for manufacturing equipment

Fiscal Year (FY)	Activity data
1990-2004	The consumption amount of diluent thinner in and before FY2004, which was estimated by multiplying the proportion of the amount to the sales volume of thinner in FY2005 by the sales volume of thinner in and before FY2004, and, deducting the amount from total sales volume of thinner, was adopted for activity data.
2005-	Estimated by deducting the consumption amount of diluent thinner for painting provided in *Summary of estimation for current status of VOC emissions from painting* (Japan Paint Manufacturers Association) from the sales amount of thinner provided in *Yearbook of chemical industry* (Ministry of Economy, Trade and Industry)

A3.1.2.2.e. Printing ink solvent use

a) Category Description

VOC from printing ink solvent or other types of diluent are emitted in the process of printing. Ink included in stationaries, solvent for cleaning of printing machine (estimated as "thinner for cleaning manufacturing equipment"), emission at the stage of production of printing ink (estimated as "A3.1.2.2.n Chemicals Manufacture") were excluded form emissions from this source category.

b) Methodological Issues

- ***Estimation Method***

VOC emissions were estimated by multiplying used weight of VOC in the process of printing, which was provided in the Studies on VOC Emission Inventories, by atmospheric emission rate.

$$E = AD * EF$$

E : NMVOC emissions from printing ink solvent use [t-NMVOC]
AD : Used weight of VOC in the process of printing [t]
EF : Atmospheric emission rate per used weight of VOC [%]

- ***Emission factor***

Atmospheric emission rate by type of ink, provided in the Studies on VOC Emission Inventories was adopted for emission factor. As for printing ink other than planographic and photogravure ink, the same atmospheric emission rate had been adopted for emission factor FY2000 and thereafter; in a similar way, atmospheric emission rate in FY2000 was adopted for and before FY1999.

As for emissions from planographic ink and photogravure ink, atmospheric emission rate for FY1990-1999 was estimated by extrapolation, using the trend in FY2000-2010: reduction tendency after FY2000 suggested that some measures aimed at reducing emissions might have been implemented during this period. (Table A 3-30) However, as for photogravure ink, the emission factor was established by interpolating, by using the result of *Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions* (Institute of Behavioral Science), since atmospheric emission rate in FY1990 would surpass 100% by simple extrapolating

calculation.

Table A 3-30 The method of establishing emission factor for the use of prinking ink solvent (Planographic ink, photogravure ink)

Fiscal Year (FY)	The method of establishing of emission factor	
	Planographic ink	Photogravure ink
1990-1999	Estimated by extrapolation, using the trend in FY2000-2010	Established by using the result of *Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions* (Institute of Behavioral Science)
2000	Established based on the Studies on VOC Emission Inventories in FY2000	
2001-2004	Established by interpolating figures in FY2000 and FY2005	
2005-	Established based on the Studies on VOC Emission Inventories in FY2000	

* The same emission factor was applied for resin anastatic ink, metallic printing inc, news ink, and other inks.

- ***Activity data***

The used amount of VOC, provided in the Studies on VOC Emission Inventories (estimated based on the result of the survey by Japan Printing Ink Makers Association and voluntary action plan of Japan Federation of Printing Industries) was used for activity data and was estimated as shown in the following Table A 3-31.

Table A 3-31 The method of estimating activity data

Fiscal Year (FY)	Activity data
1990-1999	Estimated by multiplying the sales amount of print ink by product type in FY2000, provided in Yearbook of chemical industry (Ministry of Economy, Trade and Industry), by the year ratio from FY2000.
2000	Used amount of VOC in the process of printing, provided in the Studies on VOC Emission Inventories, was used.
2001-2004	Estimated by interpolating activity data of FY2000 and 2005.
2005-	Used amount of VOC in the process of printing, provided in the Studies on VOC Emission Inventories, was used.

A3.1.2.2.f. Adhesive agent for laminate

a) Category Description

VOC are emitted by lamination, caused by solvent contained adhesive agent for bonding base material and laminate. VOC emissions from producing adhesive agent for laminate are estimated for “A3.1.2.2.n Chemicals Manufacture”.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from polyethylene laminate were estimated by multiplying the sales amount of film for laminate, which was adopted for activity data, by NMVOC emission factor per sales amount of film for laminate.

$$E = AD * EF$$

E : NMVOC emissions from lamination [t-NMVOC]
AD : Sales amount of film for laminate [t]
EF : Emission factor per sales amount of film for laminate [t-NMVOC/ t]

- ***Emission factor***

Emission factor was established by dividing VOC emissions, which was estimated based on reported value in *voluntary action plan in VOC emission inventories* by Ministry of the Environment, by sales amount of film for laminating. For fiscal years which were not subject to voluntary action plan, emission factor was established as shown in the following Table A 3-32 .

Table A 3-32 The method of establishing emission factor for lamination

Fiscal Year	The method of establishing emission factor
1990-1999	Emission factor in FY2000 was adopted for each fiscal year.
2000	Established by dividing VOC emissions from the use of adhesive agent for laminate (estimated by voluntary action plan by the sales amount of film for laminating by Japan Polyethylene Products Industrial Federation.
2001-2004	Established by interpolating emission factors for FY2000and FY2005. (According to Japan Polyethylene Products Industrial Federation, the above method cause any problems, since during the period, there was no major fluctuating factor)
2005-	Established by dividing VOC emissions by the use of adhesive agent for laminate (estimated figures by Japan Polyethylene Products Industrial Federation) by the sales amount of film for laminate.

- ***Activity data***

The sales amount of film for laminate provided in *Yearbook of paper, printing, plastics products and statistics* by Ministry of Economy, Trade and Industry was used for activity data.

A3.1.2.2.g. The use of solvent-type adhesive

a) Category Description

VOC are emitted from the use of solvent-type adhesive.

b) Methodological issues

- ***Estimation Method***

As for VOC emissions from the use of solvent-type adhesive, atmospheric emission rate was regarded as 100%; the total amount was used for estimating emissions.

$$E = AD$$

E : NMVOC emissions from the use of adhesive [t-NMVOC]
AD : The used amount of VOC from the use of adhesive [t]

- ***Emission factor***

No emission factors were established since it was assumed that total amount of emissions from the solvent used for adhesive were emitted into the air.

- ***Activity Data***

Activity data for FY2001-2004 was estimated by interpolating Ministry of the Environment the Studies on VOC Emission Inventories. Activity data for and before FY2000 was estimated by multiplying the value in FY2000 by the ratio of shipping weight of each type of adhesive to FY2000 level (Table A 3-33).

Table A 3-33 The method of establishing activity data for the use of adhesive

Fiscal year	Activity data
1990-1999	Estimated by multiplying the used amount of VOC by the ratio of shipping weight of each type of adhesive to FY2000 level.
2000	Used amount of VOC emissions provided in the Studies on VOC Emission Inventories (estimated by review meeting on the Studies on VOC Emission Inventories)
2001-2004	Estimated by interpolating, using activity data for FY2000 and FY2005
2005-	Used amount of VOC emissions provided in VOC Emission Inventories (estimated by review meeting on the Studies on VOC Emission Inventories)

A3.1.2.2.h. Gum solvent use

a) Category Description

Gum solvent-originated-VOC were emitted in the manufacturing the gum products.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from the rubber solvent were estimated by multiplying the consumption of volatile oil for solvent use, activity data, by NMVOC emission factor per consumption of volatile oil for solvent use, which was estimated based on the Studies on VOC Emission Inventories by Ministry of the Environment.

$$E = AD * EF$$

E : NMVOC emissions [t-NMVOC]
AD : Consumption of volatile oil for solvent use [t]
EF : Emission factor per consumption of volatile oil for solvent use [t-NMVOC/ t]

- ***Emission Factor***

VOC emissions per consumption of rubber solvent use, which was calculated by dividing emissions based on reported figure by Japan Rubber Manufacturers Association, by consumption of petro for solvent use were adopted for emission factor.

Table A 3-34 The method of establishing NMVOC emission factor from gum solvent use

Fiscal Year	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was applied.
2000	Established by dividing VOC emissions from volatile oil for solvent use (estimated figures based on the report by Japan Rubber Manufacturers Association) by consumption of volatile oil for solvent use
2001-2004	The median between FY2000 and FY2005 was applied.
2005-	Established by dividing VOC emissions from volatile oil for solvent use (estimated figures based on the report by Japan Rubber Manufacturers Association) by consumption of volatile oil for solvent use

- ***Activity data***

Consumption of volatile oil for solvent use, which was obtained from *Yearbook of Rubber Products Statistics* by Ministry of Economy, Trade and Industry and the survey result by Japan Rubber Manufacturers Association was applied for activity data.

As for FY2006-2010, adjustment by interpolating was conducted since during these period, surveyed business entities has possibly changed from the other period.

A3.1.2.2.i. Use of adhesive solvent and detachment solvent

a) Category Description

NMVOC were emitted by the use of adhesive solvent and detachment solvent in manufacturing adhesive tape or adhesive label. NMVOC emissions in manufacturing adhesive solvent and detachment solvent were subtracted from the emission in this source category since the emissions were included in "A3.1.2.2.n Chemicals Manufacture"

b) Methodological Issues

- ***Estimation Method***

The shipping amount of adhesive tape was used for activity data. NMVOC emissions from the use of adhesive solvent and detachment solvent were estimated by multiplying the activity data by emission factor per shipping amount.

$$E = AD * EF$$

E : NMVOC emissions from the use of adhesive and detachment solvent [t-NMVOC]
AD : Shipping amount of adhesive tape [Million m^2]
EF : Emission factor per shipping amount of adhesive tape [t-NMVOC/million m^2]

- ***Emission factor***

Emission factors per adhesive for use of solvent and detachment solvent were established by dividing emissions, which were based on the reported value in voluntary action plan by four business associations including Japan Paper Association, by the shipping amount of adhesive tape.

Table A 3-35 NMVOC emission factors for the use of adhesive and detachment solvent

Fiscal year	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was applied.
2000	Established by dividing VOC emissions (estimated based on the reported figure by four business association including Japan Paper Association) by the shipping amount of adhesive tape.
2001-2004	Established by interpolating from FY2000 and FY2005
2005-	Established by dividing VOC emissions (estimated based on the reported figure by four business association including Japan Paper Association) by the shipping amount of adhesive tape

- ***Activity data***

The shipping amount provided by Japan Adhesive Tape Manufacturers Association was adopted for activity data.

A3.1.2.2.j. Repellent and refresher

a) Category Description

NMVOC are emitted by sublimation of chemical agent in using repellent or refresher at home. Major substance in the emissions is p-dichlorobenzene. Other substances including naphthalene, camphor, and pyrethroid series are contained in repellent and refresher. However, only p-dichlorobenzene emission has been estimated; since for other substances, any quantitative data for estimation has not been available due to the lack of statistical data.

b) Methodological Issues

- ***Estimation Method***

Repellent and refresher are mainly used in general household; it is considered that total amount of them are released into the atmosphere. Therefore, atmospheric emission rate was regarded as 100% and the amount of p-dichlorobenzene contained in repellent or refresher was applied for VOC emissions.

- ***Emission factor***

It was assumed that total amount of p-dichlorobenzene contained in repellent and refresher released into the atmosphere. Therefore, no emission factor has been established.

- ***Activity data***

Total amount of p-dichlorobenzene shipped as repellent and refresher, which was provided by Japan Moth Repellent Association and indicated in *The Estimating Method of Emissions which was not Reported to PRTR* (Ministry of Economy, Trade and Industry and Ministry of the Environment) was applied for activity data.

The shipping amount provided by Japan Moth Repellent Association was not available for and before FY2000; therefore, for these period, the shipping amount was estimated by multiplying the amount for FY 2001 by the growth rate of market size from FY2001. For FY1990 and 1991, it was estimated by extrapolation.

Table A 3-36 The method of estimating activity data for repellent and refresher

Fiscal year	Activity data
1990-1991	Estimated by extrapolating from the shipping volume in FY1992-2010
1992-2000	Estimated by multiplying the shipping volume in FY2001 by the growth rate of market size of p-dichlorobenzene from FY2001.
2001-	Total amount of p-dichlorobenzene shipped as repellent and refresher, which was provided by Japan Moth Repellent Association and indicated in *The Estimating Method of Emissions which was not Reported to PRTR* (Ministry of Economy, Trade and Industry and Ministry of the Environment) was applied for activity data.

A3.1.2.2.k. Aerosols inhaler

a) Category Description

By the use of aerosols products including pesticide, lacquer, and hair spray, inhaler-originated-NMVOC are emitted. NMVOC emissions by solvent or content fluid are estimated separately for this category in the use of paint or cosmetic products. Therefore, to avoid double counting, only NMVOC emissions by liquefied gas are included in the emissions

from this source category. As for inhaler for aerosols products, propane (LPG) and dimethyl ether (DME) are mainly used.

b) Methodological Issues

- ***Estimation Method***

The emissions were estimated based on the Estimation Method provided in *Research Report on VOC emissions from private sector* by The Institute of Behavioral Science, in March in 2009. The emissions were estimated as shown in the following equation, by multiplying the production amount by type of product, by emission factors for LPG and DME.

$$E = \sum AD_i * EF_{LPG,DME}$$

E : NMVOC emissions by the use of aerosols products [g]
AD_i : Production capacity of aerosols product i [cc]
$EF_{LPG, DME}$: LPG and DME emissions per aerosols production capacity [g/cc]

- ***Emission factor***

Based on each parameter which was used by the survey by Tokyo metropolitan government, LPG and DME emission amount per aerosols production capacity was applied as the following equation.

$$EF_{LPG,DME} = R_{LPG,DME} * R_P * C_{LPG,DME} * d_{LPG,DME}$$

$EF_{LPG, DME}$: LPG and DME emissions per aerosols production capacity [g/cc]
$R_{LPG, DME}$: Percentage of LPG and DME aerosols products [%]
R_P : Percentage of aerosols propellant in can [%]
C_{LPG}, C_{DME} : Percentage of ratio of LPG and DME in propellant [%]
d_{LPG}, d_{DME} : Specific gravity of LPG and DME [g/cc]

Emission factors for LPG and DME by aerosols products were shown in Table A 3-37

Table A 3-37 Emission factors for Aerosols products (g/cc)

Type of products		LPG	DME
Pesticide	For fly and mosquito	0.223	0.0296
	Other pesticides	0.223	0.0296
Paint	Paint	0.227	0.0151
Household product	Room refresher	0.236	-
	Cleaner	0.236	-
	Wax and polish	0.236	-
	Laundry article	0.236	-
	Other household products	0.236	-
Body care products	Hair spray	0.202	0.0269
	Other hair care products	-	0.269
	Shaving cream	0.202	0.0269
	Perfume and cologne	0.112	0.134
	pharmaceutical products	0.176	0.0905
	Deodorizing and antiperspirant agent	0.225	-
	Other body care products	0.112	0.134
Car-related items	Anti-fog	0.213	-
	Other car-related products	0.213	-
Others	Handy extinguisher	-	-
	Others	0.221	-

Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

1) Percentage of aerosol products used LPG and DME as propellent

As for the percentage of aerosols products which used LPG・DME as propellant, based on the research by Tokyo metropolitan government, it was calculated that deducting each figure by product indicated in Table A 3-38 from 100%. As for paint and pharmaceutical products, 100% was applied since any data was not available. (Table A 3-39)

Table A 3-38 Percentage of aerosols products which used compassed gas as propellant aerosols

Product	Percentage
Pesticide	1.8%
Household product	6.2%
Cosmetic items	10.8%
Industrial goods	2.3%
Auto equipment	15.3%
Others	12.5%

Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

Table A 3-39 Percentage of aerosol products used LPG and DME as propellant

Type of products		Percentage
Pesticide	For fly and mosquito	98.2%
	Other pesticides	98.2%
Paint	Paint	100.0%
Household product	Room refresher	93.8%
	Cleaner	93.8%
	Wax and polish	93.8%
	Laundry article	93.8%
	Other household products	93.8%
Body care products	Hair spray	89.2%
	Other hair care products	89.2%
	Shaving cream	89.2%
	Perfume and cologne	89.2%
	pharmaceutical products	100.0%
	Deodorizing and antiperspirant agent	89.2%
	Other body care products	89.2%
Car-related items	Anti-fog	84.7%
	Other car-related products	84.7%
Others	Handy extinguisher	87.5%
	Others	87.5%

Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

* As for paint and pharmaceutical products, 100% was applied since any data was not available.

2) Percentage of propellant gas contained in aerosols cans

According to the survey by Tokyo metropolitan government, percentage of propellant gas contained in aerosols cans was estimated to be 45%.

3) Percentage of LPG and DME in propellant gas

According to the survey by Tokyo metropolitan government, percentage of LPG and DME in propellant gas was estimated as shown in the following Table A 3-40.

Table A 3-40 Percentage of LPG and DME in propellant

Type of product		LPG	DME
Pesticide	For fly and mosquito	90%	10%
	Other pesticides	90%	10%
Paint	Paint	90%	5%
Household products	Room refresher	100%	0%
	Cleaner	100%	0%
	Wax and polish	100%	0%
	Laundry article	100%	0%
	Other household products	100%	0%
Body care products	Hair spray	90%	10%
	Other hair care products	0%	100%
	Shaving cream	90%	10%
	Perfume and cologne	50%	50%
	Pharmaceutical products	70%	30%
	Deodorizing and antiperspirant agent	100.0%	0%
	Other body care products	50%	50%
Car-related products	Anti-fog	100%	0%
	Other car-related products	100%	0%
Others	Handy extinguisher	0%	0%
	Others	100%	0%

Source: *Research report on VOC emissions from public sector* (March 2009, The Institute of Behavioral Science)

4) Specific gravity of LPG and DME

According to the survey by Tokyo metropolitan government, specific gravity of LPG and DME was estimated as 0.56 and 0.67, respectively.

- ***Activity data***

According to the survey by Tokyo metropolitan government, production volume of aerosols product was applied for activity data; it was estimated by multiplying production volume of aerosols products by type of container and capacity, by average capacity per a can by type of container and capacity, then converting to capacity base.

$$AD_i = \sum N_{i,k} * P_{ave,k}$$

AD_i : Production capacity of aerosols product i [cc]
$N_{i,k}$: Production volume of aerosols Product i, Container capacity k [can]
$P_{ave,k}$: Average capacity of aerosols can in container capacity k [cc/can]

As for ”Production volume by type of container and capacity”, the result of the survey which has been annually conducted by Japan Aerosols Association was used. As for “average capacity”, setting value by type of container and capacity which was provided in the survey by Tokyo metropolitan government, based on the hearing survey to Japan Aerosols Association (shown in Table A 3-41, Table A 3-42, and Table A 3-43)

Table A 3-41 Average capacity by capacity class (Tinplate container)

Capacity class [cc]	420-	280-	220-	180-	150-	100-
Average capacity[cc]	420	350	250	200	165	125

Table A 3-42 Average capacity by capacity class (Aluminum container)

Capacity class [cc]	300-	200-	150-	100-	50-	-49
Average capacity[cc]	300	250	175	125	75	25

Table A 3-43 Average capacity by capacity class (Synthetic resin container)

Capacity class [cc]	*
Average capacity[cc]	210

* Same for all capacity class
Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

A3.1.2.2.l. Cosmetic products

a) Category Description

Following to the methodology of the survey by Tokyo metropolitan government, VOCs contained in various types of cosmetic products are emitted to the atmosphere by the use of cosmetics.

b) Methodological Issues

- ***Estimation Method***

VOC emissions were estimated by multiplying sales amount of cosmetic product by type, by VOC content rate by type of cosmetic product, by atmospheric emission rate by type of cosmetic product

$$E = \sum_i (AD_i * C_i * EF_i)$$

E : NMVOC emissions by the use of cosmetic product [t-NMVOC]
AD_i : Sales amount of cosmetic items i [t]
C_i : VOC content rate in cosmetic products i [%]
EF_i : Atmospheric emission rate of cosmetic products i [%]

- ***Emission factor***

VOC content rate of products was classified according to *Yearbook of chemical industry* from VOC content rate which was provided in the survey by Tokyo metropolitan government which is based on some reports. (Table A 3-44)

The smaller classified categories in the survey by Tokyo metropolitan government than in *Yearbook of chemical industry* were integrated by weighted average using shipping amount allocated ratio provided in *Cosmetic Products Marketing Directory* (Fuji Keizai CO., Ltd.)., corresponding to categories in *Yearbook of chemical industry*.

Table A 3-44 VOC content rate based on classification in Yearbook of chemical industry

Cosmetic products		VOC content rate
Skin care	Massage and Cold cream	7.5%
	Moisturizing cream	7.5%
	Cleansing foam	10.0%
	Cleansing cream	10.0%
	Lotion	10.0%
	Milk	6.0%
	Beauty essence	8.5%
	Facial mask*	4.4%
	Other skincare products	7.5%
Makeup	Foundation*	2.6%
	Face powder	0.0%
	Eye makeup	4.0%
	Eyebrow and eyelash cosmetics	0.0%
	Cheek rouge	0.0%
	Lip rouge	0.0%
	Nail cosmetic (including nail-polish remover) *	76.8%
Fragrance	Perfume and cologne	7.5%
Body care	Lip balm	10.0%
	Sunscreen and cosmetics for sun burning	83.5%
Hair care in bath	Shampoo	1.5%
	Rinse	1.5%
	Hair conditioner	1.5%
Hair making	Pomade, hair oil, hair dress, perfume oil* Hairdressing*, Setting lotion*	10.6%
	Hair spray	27.5%
	Other items for hair (including permanent wave lotion)	1.5%
Hair color	Hair color (Including hair bleach)*	22.1%
For men	Products for shaving or bath	25.0%
	Skin care products	7.5%
	Hair tonic (Including hair growing agent)	42.5%

* Integrated categories by weighted average
Source: *Research report on VOC emissions from public sector*, March 2009, The Institute of Behavioral Science

As for atmospheric emission rate, as well as VOC content rate, the atmospheric emission rate in

category was reset (Table A 3-45) so that it corresponds to category in *Yearbook of chemical industry*. By using cosmetic products in a normal way, atmospheric emission rate of solid products and liquid products were roughly set at either 0% or 100% (Table A 3-46 and Table A 3-47).

Table A 3-45 Atmospheric emission rate based on clarification in Yearbook of Chemical Industry

Cosmetic items		Atmospheric emission rate
Skin care	Massage and Cold cream	100%
	Moisturizing cream	100%
	Cleansing foam	0%
	Cleansing cream	0%
	Lotion	100%
	Milk	100%
	Beauty essence	100%
	Facial mask	100%
	Other skincare products	100%
Makeup	Foundation	100%
	Face powder	100%
	Eye makeup	100%
	Eyebrow and eyelash cosmetics	100%
	Cheek rouge	100%
	Lip rouge	100%
	Nail cosmetic (including nail-polish remover)	100%
Fragrance	Perfume and cologne	100%
Body care	Lip balm	100%
Fragrance	Sunscreen and cosmetics for sun burning	100%
Hair care in bath	Shampoo	0%
	Rinse	0%
	Hair conditioner	0%
Hair making	Pomade, hair oil, hairdress, perfume oil	100%
	Hairdressing	100%
	Setting lotion	100%
Hair color	Hair spray	100%
For men	Other items for hair (including permanent wave lotion)	100%
	Hair color (Including hair bleach)	100%
	Products for shaving or bath	100%

Table A 3-46 Atmospheric emission rate by the way of usage, provided in the survey by Tokyo Metropolitan Government

State of matter	Usage and process	Atmospheric emission rate
Solid	To use in water or wash away	0%
	To leave it and volatilize component	100%
Liquid	To use in water or wash away in a short time	0%
	To leave in for a long time and dry it	100%
	To volatilize component	100%
	To spray mist (Only undiluted solution used for estimation. Propellant solvent is separately estimated.)	100%

Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

Table A 3-47 Atmospheric emission rate based on the survey by Tokyo metropolitan government

Cosmetic products			Atmospheric emission rate
Skin care	Massage and Cold cream *1		100%
	Remover		0%
	Facial-wash	Facial-wash	0%
		Cleansing	0%
	Lotion	Lotion	100%
	Milk	Milk	100%
	Beauty essence	Beauty essence	100%
	Facial mask	Wash-off facial mask	0%
		Peel-off pack	100%
		Sheet pack	100%
	Face cream	(included in *1)	-
	Others	Spot care	100%
Makeup	Base	Makeup base	100%
	Foundation, concealer	Foundation, and etc.	100%
	Face powder	Face powder	100%
	Eye color	Eye shadow	100%
	Eye liner	Eye liner	100%
	Eyelash liner	Eyelash liner	100%
	Eyebrow	Eyebrow	100%
	Cheek rouge	Cheek rouge	100%
	Lip color	Lip color	100%
	Nail color	Nail enamel	100%
		Nail care (including remover)	100%
Body care	Body cream, lotion	Body cream, lotion, etc.,	100%
	Lip cream	Lip cream	100%
	Hand cream	Hand cream	100%
	UV care product	Suntan, sunscreen	100%
	Unwanted hair treatment agent	Hair removal, Depilatory	100%
	Anhidrotic deodorant *2	Deodorant (For foot, For underarm)	100%
Fragrance	Perfume *3	Parfum, Eau de Parfum,	0%
	Eau du toilette *3		100%
	Cologne *3		0%
Hair care in bath	Shampoo	Shampoo	0%
	Rinse, Hair conditioner	Rinse, Hair conditioner	0%
	Hair treatment, pack	Hair treatment	0%
Hair make	Blow styling agent, Hair spray, Hair gross	Hair styling agent	100%
	Hair tonic for female	(*Classified into *6)	-
	Hair growing agent for female	(*Classified into *7)	-
	Permanent wave lotion	Cold wage treating agent	100%
Hair color	Hair coloring agent for black hair, Hair coloring agent for white hair*4	Hair coloring agent for white hair	100%
		Hair coloring agent for black hair	100%
		Hair manicure for white hair	100%
		Hair manicure for black hair	100%
		Other types of haircolor (including spray)	100%
		Bleach (decoloring)	100%
For men	Pre-shaving agent, shaving agent	Shaving agent	100%
	Face wash, pack	Skin care products	0%
	Skin lotion		100%
	Skin cream and milk		0%
	Make-up items		0%
	Hair tonic for men *6	Hair tonic	100%
	Hair growing agent *7	*7 Hair growing agent, tonic	100%
	Blow styling agent	(* classified into *4)	-
	Hair spray, hair gross		0%
	Hair coloring agent for black hair	(*classified into *5)	-
	Hair coloring agent for white hair	(*classified into *5)	-
	Anhidrotic deodorant	(*classified into *2)	-
	Fragrance	(*classified into *3)	-

Source: *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

- ***Activity data***

Sales amount of cosmetic products by types provided in *Yearbook of chemical industry* (Ministry of Economy, Trade and Industry) used for activity data. However, since import goods are not included in *Yearbook of chemical industry* (Ministry of Economy, Trade and Industry) there might be a wide gap between reported sales amount and actual consumption amount. Therefore, as for "perfume and cologne", since the percentage of import excess was especially high, correction measures were conducted.

Table A 3-48 Cosmetic products provided in yearbook of chemical industry

Skin care	Massage and Cold cream
	Moisturizing cream
	Cleansing foam
	Cleansing cream
	Lotion
	Milk
	Beauty essence
	Facial mask
	Other skincare products
Makeup	Foundation
	Face powder
	Eye makeup
	Eyebrow and eyelash cosmetics
	Cheek rouge
	Lip rouge
	Nail cosmetic (including nail-polish remover)
Fragrance	Perfume and cologne
Body care	Lip balm
	Sunscreen and cosmetics for sunburning
Hair care in bath	Shampoo
	Rinse
	Hair conditioner
Hair making	Pomade,hair oil, hairdness, perfume oil
	Hairdressing
	Setting lotion
	Hair spray
	Other items for hair (including permanent wave lotion)
Hair color	Hair color (Including hair bleach)
For men	Products for shaving or bath
	Skin care products
	Hair tonic (Including hair growing agent)

A3.1.2.2.m. Products for car washing and repair

a) Category Description

VOC components contained in various products for car washing and repairing including wax and cleaner are emitted into the air.

b) Methodological Issues

- ***Estimation Method***

Following to the methodology of the survey by Tokyo metropolitan government, VOC amount used was estimated by multiplying production amount of car repairing and washing products by type of products, by VOC content rate by type of product. All amount of VOC contained in car repairing and washing products are assumed to emit into the air by the use of the products, the

used amount of VOC are applied for VOC emissions from this source category.

$$E = \sum_i (AD_i * C_i)$$

E : NMVOC emissions by the use of car washing and repairing products. [t-NMVOC]
AD_i : The production amount of i [t]
C_i : VOC content rate of car washing and repairing products i [%]

- ***Emission factor***

VOC content rate was newly established based on various statistical data and existing VOC content rate provided in the survey by Tokyo metropolitan government; as for some whose minimum value and maximum value was indicate, median value was calculated.(Table A 3-49)

Table A 3-49 VOC content rate for car washing and reparing products

Product		VOC	VOC content rate
Wax for cars, Coating material		Hydrocarbon compounds Including kerosene	50.0%
Products for car window	Window washer Fluid	Methanol	25.0%
	Water repellent product	Ethanol	49.0%
		Isopropyl alcohol	42.0%
	Oil film remover	Ethanol	6.5%
		Isopropyl alcohol	12.5%
		Diethanolamine	5.0%
		Petroleum solvent	30.0%
	Frost remover	Ethylene glycol	25.0%
		Isopropyl alcohol	25.0%
Car cleaner		Ethylene glycol	10.0%
Paint for car, Repairing agent	Paint		-
	Adhesive		-
Air fresher and air refresher for car	Air fresh	Aroma chemical (liquid)	1.5%
		Ethanol	2.3%
		Methanol	3.5%
		Aroma chemical (gel)	3.5%
	Air refresher	Ethanol	50.0%

Source: Based on *Research report on VOC emissions from public sector* (March, 2009, The Institute of Behavioral Science)

- ***Activity data***

Production weight by type of chemical products for car indicated in *Research report on the current status of auto chemical manufacturing* (Japan Auto Chemical Industry Association) was used for activity data. Activity data in FY2006 and thereafter was estimated by multiplying consumption of car washing and repairing products per vehicle by number of registered vehicles provided in *Statistical Yearbook of Motor Vehicle Transport* (Ministry of Land, Infrastructure, Transport and Tourism).

Consumption of car washing and repairing products per vehicle was estimated by dividing production weight by type of chemical products for car by number of registered vehicles in FY2005. The consumption of wax and coating material for car has been showing a downward trend since FY1990. According to Auto-parts & Accessories Retail Association, recently, consumption per one vehicle has been decreasing due to a decline in the rate of utilization of car,

miniaturization of car, and the prevalence of car washing machine. Therefore, in consideration of trend of travel distance per vehicle, the consumption weight of wax and coating material for car per vehicle in and after FY2006 was estimated by multiplying the average consumption weight of wax and coating material for car per vehicle for three years (FY2003-2005) by the growth rate of travel distance per vehicle.

The consumption weight of other products for car was also estimated multiplying by the growth rate of travel distance per vehicle.

Table A 3-50 The method of establishing of activity data in using car washing and repairing products

Fiscal Year	Activity data
1990	The value for FY1991 was used.
1991-1996	Production weight of chemical products for car by type provided in *Research report on the current status of auto chemical manufacturing* (Japan Auto Chemical Industry Association) was used.
1997, 1998	Estimated by interpolating, using activity data in FY1996 and FY1999
1999-2005	Production weight of products for car by type provided in *Research report on the current status of auto chemical manufacturing* (Japan Auto Chemical Industry Association) was used.
2006-	Estimated by multiplying consumption weight of car washing and repairing products per vehicle by number of registered vehicles (*Statistical Yearbook of Motor Vehicle Transport*). Consumption of car washing and repairing product per vehicle was estimated by dividing production weight of products for car by type by number of registered vehicles in FY2005, provided in *Statistical Yearbook of Motor Vehicle Transport* (Ministry of Land, Infrastructure, Transport and Tourism). Consumption of car washing and repairing products in and from FY2006 onward was estimated by multiplying the average of consumption of the products per vehicle for three years (FY2003-2005) by travel distance per vehicle.

A3.1.2.2.n. Chemicals Manufacture

a) Category Description

This source category provides the methods for estimating NMVOC fugitive emissions from highly-volatile substance in manufacturing facilities to polymerize or synthesize chemical products, fugitive emissions by storage or shipping of chemical products, and emissions from solvent in chemical reaction by polymerizing or component extraction.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions by chemicals manufacture were estimated by multiplying each activity data (Production amount of paint, production amount of print ink, shipping amount of solvent-type adhesive, amount of VOC of surface finishing equipment, shipping value of chemical industry-related products and production amount of film soft chemical products for wrapping) by each NMVOC emission factor (per activity data) defined by dividing VOC emissions for the Studies on VOC Emission Inventories (Ministry of the Environment) by activity data.

$$E = AD * EF$$

E : NMVOC emissions by chemical manufacture [t-NMVOC]
AD : Activity data by emission sources
EF : Emission factor per sales amount of laminating film [t-NMVOC/ t]

This emission are also included the emission from chemical tanker estimated in A3.1.1.3.b Oil transport (1.B.2.a.iii): Navigation. Therefore, the emissions from chemical tanker were subtracted from total emissions in this category.

- ***Emission factor***

Emission factor was established by dividing emissions from emission activities indicated in the Studies on VOC Emission Inventories (Ministry of the Environment) by each activity data shown in Table A 3-57. In FY1990 to FY1999 and FY2001 to FY2004, emission factor was established as shown in the following Table A 3-51 - Table A 3-56.

Table A 3-51 The method of establishing NMVOC emission factor for chemical manufacture (Paint manufacturing)

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was used for all fiscal years.
2000	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Paint Manufacturers Association) by production amount of paint.
2001-2004	Median value of FY2000 and 2005 was used.
2005-	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Paint Manufacturers Association) by production amount of paint.

Table A 3-52 The method of establishing NMVOC emission factor for chemical manufacture (Print ink manufacturing)

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was used for all fiscal years.
2000	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Printing Ink Makers Association) by production amount of print ink.
2001-2004	Median value of FY2000 and 2005 was used.
2005-	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Printing Ink Makers Association） by production amount of print ink.

Table A 3-53 The method of establishing NMVOC emission factor for chemical manufacture (Solvent-type adhesive manufacturing)

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was used for all fiscal years.
2000	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Adhesive Industry Association) by shipping amount of solvent-type adhesive.
2001-2004	Median value of FY2000 and 2005 was used.
2005-	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Adhesive Industry Association) by shipping amount of solvent-type adhesive.

Table A 3-54 The method of establishing NMVOC emission factor for chemical manufacture (Manufacturing of surface wood finishing equipment)

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was used for all fiscal years.
2000	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Surface Finishing Suppliers Association) by used amount of VOC by manufacturing of surface finishing equipment.
2001-2004	Median value of FY2000 and 2005 was used.
2005-	Established by dividing VOC emissions (estimated figure based on voluntary action plan by Japan Surface Finishing Suppliers Association) by used amount of VOC by manufacturing of surface finishing equipment.

Table A 3-55 The method of establishing NMVOC emission factor for chemical manufacture (Manufacturing of various chemical products)

Fiscal Year (FY)	The method of establishing emission factor
1990-1994	Since any aggressive actions to reduce emissions have not been taken, emission factor for FY1995 was used for all fiscal years.
1995-1999	Since voluntary actions has been started in FY1995, it is considered that emissions were on a downward trend since then. Therefore, it was estimated by extrapolating, using the trend for 2000-2010. (*)
2000	Established by dividing VOC emissions from chemical industry (estimated figure based on voluntary action plan by Japan Chemical Industry Association) by shipping value of chemical industry-related products.
2001-2004	Estimated by interpolating, using emission factors in FY2000 and 2005.
2005-	Established by dividing VOC emissions from chemical industry (estimated figure based on voluntary action plan by Japan Chemical Industry Association) by shipping value of chemical industry-related products.

In the case that emission factor for FY1990-1999 is established by extrapolating, it should be established based on the trend for and before FY2010.

Table A 3-56 The method of establishing emission factor for chemical manufacture (Cellophane manufacturing)

Fiscal Year (FY)	The method of establishing emission factor
1990-1999	Emission factor for FY2000 was applied for all fiscal year.
2000	Established by dividing VOC emission amount by cellophane manufacturing (emissions reported to PRTR) by production amount of film soft chemical products for wrapping
2001-2004	Median value of FY2000 and 2005 was used.
2005-	Established by dividing VOC emission amount by cellophane manufacturing (emissions reported to PRTR) by production amount of film soft chemical products for wrapping.

- ***Activity data***

The following data indicated in the Table A 3-57 was used for activity data, since it is considered to be correlated to each emission activities. As for “Manufacturing of various chemical products”, total shipping value for all various chemical products was used for activity data since specific chemical product was not able to selected from many chemical products provided in voluntary action plan by Japan Chemical Industry Association.

Since total shipping value of calendar year is only available, the value was converted from calendar year to fiscal year using following equation.

$$S_{FYi} = S_{CYi} * 0.75 + S_{CY(i+1)} * 0.25$$

S : Shipping value
FY_i : Fiscal Year i
CY_i : Calendar Year i

Table A 3-57 Activity data for chemical manufacture

Emission Source	Activity data	Source
Paint manufacturing	The production amount of paint	*Yearbook of chemical industry*, Ministry of Economy, Trade and Industry
Print ink manufacturing	The production amount of print ink	*Yearbook of chemical industry*, Ministry of Economy, Trade and Industry
Solvent-type adhesive manufacturing	The shipping amount of solvent-type adhesive	*Current Survey Report on Adhesive*, Japan Adhesive Industry Association
Manufacturing of surface finishing equipment	VOC emissions by manufacturing surface finishing equipment *For FY1990-1999, the value for FY2000 was applied. For FY2001-2004, the average of the value for FY2000 and 2005 was used.	*VOC voluntary action plan and achievement report*, Ministry of Economy, Trade and Industry
Manufacturing of various chemical products	Total shipping value of various chemical products reported in PRTR in voluntary action plan. (“Chemical industry” and “Manufacturing plastic products which were excluded separately reported”)	*Census of manufactures*, Ministry of Economy, Trade and Industry
Cellophane manufacturing	The production amount of film-soft chemical products for wrapping.	*Yearbook of Paper, Printing, Plastics Products and Rubber Products Statistics*, Ministry of Economy, Trade and Industry

A3.1.2.3. Others – Food and beverage industry (2.H.2.) (NMVOC)

A3.1.2.3.a. Foods (Fermentation)

a) Category Description

NMVOC are released as a fugitive emission in alcohol in the process of manufacturing foods or beverages. For the estimation of NMVOC emissions from this source category, alcohol which is generated by bread making and alcoholic brewing is included in calculation; it is considered to be biogenic-origin.

b) Methodological Issues

- ***Estimation Method***

NMVOC emissions from manufacturing foods or beverage were estimated by multiplying activity dada, the production amount of bread and alcohol drinks, by NMVOC emission factor per production amount of bread and alcohol drinks.

➢ ***Calculation of NMVOC emissions from bread making***

$$E = AD * EF$$

E : NMVOC emissions from bread making [t -NMVOC]
AD : Production amount of bread [1000 t]
EF : Emission factor per production amount of bread [kg-NMVOC/t]

➢ ***Calculation of NMVOC emissions from alcoholic brewing***

$$E = AD * ABV * EF$$

E : NMVOC emissions from alcoholic brewing [t -NMVOC]
AD : Production volume of alcoholic drinks [1000 kL]
ABV : Ethyl alcohol content rate [%] (only for Shochu (Japanese distilled spirit), whiskey, spirits, and liqueur)
EF : Emission factor per production amount of alcoholic drinks [kg-NMVOC/kL]

● ***Emission factor***

Emission factor (4.5kg/t) for bread making, provided in European Environment Agency's *EMEP/EEA air pollutant emission inventory guidebook 2009*, was used for emission factor for bread making.

As for emission factor for brewing alcoholic drinks, ethyl alcohol content rate of shochu, whiskey, spirits and liquor, provided in European Environment Agency's *EMEP/EEA air pollutant emission inventory guidebook 2009* was basically used. (Table A 3-58 and Table A 3-59)

However, under the alcohol tax in Japan, liquor includes low-alcohol content beverage including shochu-based beverage, chuhai, or newly-marketed alcohol beverage. Therefore, alcohol content rate of liqueur in Japan was established as 7%[7].

Table A 3-58 Ethyl alcohol content rate for alcoholic drinks

Alcoholic drinks	Ethyl alcohol content rate	
	Inventory guidebook 2009	Rate for the estimation
Shochu (Japanese distilled spirit)	25%	25%
Whiskey	40%	40%
Spirits	40%	40%
Liqueur	40%	7%

Based on *EMEP/EEA air pollutant emission inventory guidebook 2009*

Table A 3-59 Emission factors for brewing alcoholic drinks

Alcoholic drinks	Emission factor	Unit
Refined sake	0.08	kg/100L- volume of brewed alcoholic drinks
Synthetic refined sake	0.08	kg/100L- volume of brewed alcoholic drinks
Shochu (Japanese distilled spirit)	0.4	kg/100L- volume of brewed ethyl alcohol
Beer	0.035	kg/100L- volume of brewed alcoholic drinks
Fruit wine	0.08	kg/100L- volume of brewed alcoholic drinks brewed volume
Whiskey	15	kg/100L- volume of brewed ethyl alcohol
Spirits	0.4	kg/100L- volume of ethyl alcohol
Liqueur	0.4	kg/100L- volume of brewed ethyl alcohol
Other liquors (including low-malt beer)	0.035	kg/100L-volume of brewed alcoholic drinks

Based on *EMEP/EEA air pollutant emission inventory guidebook 2009*, established by using Ministry of the Environment, the Studies on VOC Emission Inventories.

[7] According to the survey for *National Health Nutrition Survey* by Ministry of Health Labour and Welfare, alcohol content of shochu-based beverage is 7%.

- ***Activity data***

As for bread, production amount of various kind of bread, provided in *Yearbook of rice and wheat processed food production statistics* (Ministry of Agriculture, Forestry and Fisheries of Japan), was used for activity data.

As for alcoholic drinks, volume of brewed alcoholic drinks, provided in Table of volume of brewed alcoholic drinks and stock in hand (The National Tax Administration Agency) was used for activity data.

A3.1.3 Agriculture

A3.1.3.1. Field burning of agricultural residues (3.F: CO, NOx)

a) Methodological Issues

- ***Estimation Method***

CO and NOx emissions were calculated by using the method indicated in the *2006 IPCC Guidelines*, which is same method with CH_4 and N_2O estimation.

$$E = A \times M_B \times C_f \times G_{ef} \times 10^{-3}$$

E	: CH_4 and N_2O emissions from field burning of agriculture residues [t-CO or t-NOx]
A	: Area burnt [ha]
M_B	: Mass of fuel available for combustion [t/ha]
C_f	: Combustion factor
G_{ef}	: emission factor [g-CO/kg or g-NOx/kg]

- ***Emission factor***

CO: 92 g-CO/kg (dry matter) (default value in the *2006 IPCC Guidelines*)
NOx: 2.5 g-NOx/kg (dry matter) (default value in the *2006 IPCC Guidelines*)

- ***Activity data***

Activity data are same with CH_4 and N_2O estimation described in "5.7. Field Burning of Agricultural Residues (3.F.)".

A3.1.4 Land Use, Land-Use Change and Forestry

a) Methodological Issues

1) Biomass burning (4(V))Forest land

- ***Estimation Method***

For CO and NO_X emissions due to biomass burning from forest fires, Tier 1 method is used.

➢ ***CO***

$$bbGHG_f = L_{forestfires} \times ER$$

➢ ***NO_X***

$$bbGHG_f = L_{forestfires} \times ER \times NC_{ratio}$$

$bbGHG_f$: GHG emissions due to forest biomass burning
$L_{forest\ fires}$: Carbon released due to forest fires [tC/yr]
ER : Emission ratio (CO: 0.06, $NO_{X:}$ 0.121)
NC_{ratio} : NC ratio

- ***Emission Factor***

- ***Emission ratio***

The following values are applied to emission ratios for CO and NO_X due to biomass burning.

CO: 0.06, NO_X: 0.121

(default value stated in the GPG-LULUCF, Table 3A.1.15)

- ***NC ratio***

The following values are applied to NC ratio of NO_X.

NC ratio: 0.01 (default value stated in the GPG-LULUCF p.3.50)

- ***Activity data***

For activity data in Forest land, carbon released by forest fire is used. For detailed information, see the description on the activity data in section 6.16 in Chapter 6.

2) **From burning of pruned branches from orchard trees**

- ***Estimation Method***

For CO and NOx emissions due to biomass burning of pruned branches from orchard trees, the estimation method (Equation 2.27, p2.42, Vol.4) described in the *2006 IPCC Guidelines* is applied. The estimation equation is as follows:

$$L_{fire} = W_B \times C_f \times G_{ef} \times 10^{-6}$$

L_{fire} : Amount of greenhouse gas emission form fire [kt- GHG]
W_B : Amount burnt [t-d.m.]
C_f : Combustion factor
G_{ef} : Emission factor [t/kt-d.m.]

- ***Parameters***

For the combustion factor, a general value (0.9) which has been used generally in field burning of crop residues in agriculture in Japan is applied. The default emission factors (Agricultural residue value) described in the *2006 IPCC Guidelines* are used.

Table A 3-60 Emission factors (t/kt-d.m.)

Category	CO	NOx
Agricultural residue	92	2.5

2006 IPCC Guidelines, Vol.4, chp.2, Table 2.5

- ***Activity Data (Amount burned)***

For activity in orchard land, see the description on the activity data in section 6.16 in Chapter 6.

A3.1.5 Wastes

A3.1.5.1. Waste incineration (5.C.)

A3.1.5.1.a. Municipal Solid Waste Incineration (5.C.–)

- ***Estimation Method***

The NO_X, CO, NMVOC, and SO_X emissions from the specified sources were calculated by multiplying the incineration amount of MSW in each incinerator type (Continuous Incinerators, Semi-continuous Incinerators, Batch type Incinerators, Gasification melting furnaces) by Japan's country-specific emission factors. These emissions are categorized following the methods given in chapter 7 based on incinerations either with or without energy recovery. The former emissions are reported in the Energy sector, while the latter are reported in the Waste sector.

- ***Emission factors***

➢ ***NO_X, SO_X***

For incinerators, emission factors were established for each incinerator type by using the emission amount and amount of treated waste identified in the *General Survey of the Emissions of Air Pollutants*. (The categories of incinerator types included: [1301: Waste incinerator (municipal solid waste; continuous system)] and [1302: Waste incinerator (municipal solid waste; batch system)]). The incineration material was [53: Municipal solid waste].) It is noted that while the *General Survey of the Emissions of Air Pollutants* classified the incinerators into two classes (Continuous and Batch), this report classifies incinerators into three classes ("Continuous", "Semi-continuous", and "Batch type") by dividing the Continuous system and assigning those which operated for less than 3,000 hours to the "Semi-continuous" class.

For gasification melting furnaces, the value for Continuous Incinerators with a similar incineration method was used.

Table A 3-61 NO_X and SO_X emission factors for municipal waste incineration by facility type

	Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NOx	Continuous Incinerator	kg-NOx/t	1.238	1.213	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127
	Semi-Continuous Incinerator	kg-NOx/t	1.055	1.226	1.226	1.226	1.226	1.226	1.226	1.226	1.226	1.226	1.226	1.226	1.226
	Batch type Incinerator	kg-NOx/t	1.137	1.918	1.850	1.850	1.850	1.850	1.850	1.850	1.850	1.850	1.850	1.850	1.850
	Gasification melting furnace	kg-NOx/t	1.238	1.213	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127	1.127
SOx	Continuous Incinerator	kg-SO_2/t	0.555	0.539	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361
	Semi-Continuous Incinerator	kg-SOx/t	0.627	1.141	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712	0.712
	Batch type Incinerator	kg-SOx/t	1.073	1.625	1.714	1.714	1.714	1.714	1.714	1.714	1.714	1.714	1.714	1.714	1.714
	Gasification melting furnace	kg-SOx/t	0.555	0.539	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361

The data for 2000 were used for 2001 and subsequent years.
Source: *General Survey of the Emissions of Air Pollutants* (Ministry of the Environment)

➢ ***CO***

For incinerators, based on the emission factors for individual facilities summarized in the *Report on Emission Factor Results for Combustion Facilities* (Japan Society for Atmospheric Environment, 1997) as well as other reports, the emission factors were established for each incinerator class. It is noted that while the Japan Society for Atmospheric Environment report subdivided the facilities by furnace type (e.g., stoker, fluidized bed, etc.), this report determined the emission factors for three classes of "Continuous", "Semi-continuous" and "Batch type" by taking the average weighted by incinerated amount for each furnace.

For gasification melting furnaces, the value for continuous stoker furnaces with a similar incineration method was used.

Table A 3-62 CO emission factors for municipal waste incineration by facility type

	Furnace Type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
CO	Continuous Incinerator	g-CO/t	557	557	555	554	554	554	554	554	554	553	553	553	553
	Semi-Continuous Incinerator	g-CO/t	548	548	567	591	607	610	613	605	611	609	613	609	609
	Batch type Incinerator	g-CO/t	8,237	8,237	8,298	8,341	8,344	8,347	8,343	8,351	8,270	8,272	8,270	8,274	8,274
	Gasification melting furnace	g-CO/t	567	567	567	567	567	567	567	567	567	567	567	567	567

Source: *Report on Emission Factor Results for Combustion Facilities* (Japan Society for Atmospheric Environment, 1997), and others.

➢ ***NMVOC***

For both incinerators and gasification melting furnaces, NMVOC emission factors were established by multiplying the CH_4 emission factors for each furnace type of each fuel type by "NMVOC/CH_4", the emission ratio for fuel type. The ratio was determined by using the reference material by Japan Environmental Sanitation Center and Institute of Behavioral Science, which estimated CH_4 and NMVOC emissions per unit calorific value.

Table A 3-63 NMVOC emission factors for municipal waste incineration by facility type

	Furnace Type	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NMVOC	Continuous Incinerator	g-NMVOC/t	0.9	0.9	0.9	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Semi-Continuous Incinerator	g-NMVOC/t	7.8	7.8	8.5	2.2	2.3	2.3	2.4	2.3	2.4	2.3	2.4	2.3	2.3
	Batch type Incinerator	g-NMVOC/t	9.1	9.1	9.5	1.5	1.5	1.5	1.5	1.5	1.3	1.3	1.3	1.3	1.3
	Gasification melting furnace	g-NMVOC/t	-	-	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Source: *Report on Screening Survey Regarding Measures to Counter Global Warming* (Japan Environmental Sanitation Center, 1989), *Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions* (Institute of Behavioral Science, 1984)

- ***Activity data***

For incinerators, the activity data used was the incineration amount for each facility type as calculated by multiplying the incineration amount of municipal waste by the incineration rate for each facility type. The incineration amount data were extracted from the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes* (the Volume on Cyclical Use) by Ministry of the Environment. The incineration rate was calculated in the *Waste Treatment in Japan* published by Ministry of the Environment.

For gasification melting furnaces, the activity data used was the amount incinerated in gasification melting furnaces, calculated from data in Ministry of the Environment's "*Waste Treatment in Japan*."

A3.1.5.1.b. Industrial Wastes Incineration (5.C.–)

- ***Estimation Method***

NO_X, CO, NMVOC, and SO_X emissions from the specified sources were calculated by multiplying the incineration amount of industrial waste for each waste type by Japan's country-specific emission factors. These emissions are categorized following the methods given in chapter 7 based on incinerations either with or without energy recovery. The former emissions are reported in the Energy sector, while the latter are reported in the Waste sector.

- ***Emission factors***

➢ ***NO_X, SO_X***

An emission factor was established for each type of industrial solid waste using the emission amount and amount of treated industrial solid waste identified by the *General Survey of the Emissions of Air Pollutants*. The categories of incinerator types included: [1303: Waste

incinerator (industrial solid waste; continuous system)] and [1304: Waste incinerator (industrial solid waste; batch system)]. The incinerator fuel covered the categories [23: Fuel Wood] and [54: Industrial solid waste]). The six types of industrial waste were “Waste paper or waste wood”, “Sludge”, “Waste oil”, “Waste plastics”, “Waste textiles”, and “Animal/plant residue, livestock carcasses”. Category [23: Sawn Timber] was used for “Waste paper or waste wood”, “Waste textiles”, and “Animal/plant residues, livestock carcasses”, while category [54: Industrial waste] was used for “Sludge”, “Waste oil”, and “Waste plastics”. However, no emission factor was set for the mixed burning of multiple waste types.

Table A 3-64 NO_X and SO_X emission factors for industrial waste by facility type

	Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NOx	"Fuel Wood 23"	kg-NOx/t	1.545	1.312	5.828	5.828	5.828	5.828	5.828	5.828	5.828	5.828	5.828	5.828	5.828
	"Industrial Waste 54"	kg-NOx/t	0.999	1.158	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415
SOx	"Fuel Wood 23"	kg-SOx/t	1.528	1.274	2.118	2.118	2.118	2.118	2.118	2.118	2.118	2.118	2.118	2.118	2.118
	"Industrial Waste 54"	kg-SOx/t	1.179	1.882	1.352	1.352	1.352	1.352	1.352	1.352	1.352	1.352	1.352	1.352	1.352

The data for 2000 were used for 2001 and subsequent years.
Source: *General Survey of the Emissions of Air Pollutants* (Ministry of the Environment)

- ***CO***

Based on the emission factors for individual facilities summarized in the *Report on Emission Factor Results for Combustion Facilities* (Japan Society for Atmospheric Environment, 1997) as well as other reports, an emission factor was established for each type of industrial solid waste. The six types of industrial waste were “Waste paper or waste wood”, “Sludge”, “Waste oil”, “Waste plastics”, “Waste textiles”, and “Animal/plant residues, livestock carcasses”. The emission factor for “wood waste” was used for “Waste textiles” and “Animal/plant residues, livestock carcasses”, for which there are no measurements. No emission factor was set for the mixed burning of multiple waste types.

Table A 3-65 CO emission factors for industrial waste incinerators by operation type

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Paper/cardboard, Wood	g-CO/t	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334
Waste Oil	g-CO/t	127	127	127	127	127	127	127	127	127	127	127	127	127
Plastics	g-CO/t	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790
Sludge	g-CO/t	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285	2,285
Textile	g-CO/t	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334
Animal and vegetable residues/ animal carcasses	g-CO/t	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334

Source: *Report on Emission Factor Results for Combustion Facilities* (Japan Society for Atmospheric Environment, 1997) and others

- ***NMVOC***

NMVOC emission factors were established by multiplying the CH_4 emission factors for each furnace type of each fuel type by “NMVOC/CH_4”, the emission ratio for fuel type. The ratio was determined by using the reference materials by Japan Environmental Sanitation Center and Institute of Behavioral Science, which estimated CH_4 and NMVOC emissions per unit calorific value.

Table A 3-66 NMVOC emission factors for industrial waste incineration by facility type

Item	Unit	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Paper/cardboard, Wood	g-NMVOC/t	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Waste Oil	g-NMVOC/t	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Plastics	g-NMVOC/t	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Sludge	g-NMVOC/t	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61
Textile	g-NMVOC/t	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
Animal and vegetable residues/ animal carcasses	g-NMVOC/t	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48

Source: *Report on Screening Survey Regarding Measures to Counter Global Warming* (Japan Environmental Sanitation Center, 1989), *Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions* (Institute of Behavioral Science, 1984)

- ***Activity data***

The activity data used the incineration amount data for each type of waste extracted from the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes* (the Volume on Cyclical Use) and the *Waste Treatment in Japan* published by Ministry of the Environment.

A3.1.5.1.c. Incineration in Conjunction with Use of Waste as Fuel and Raw Material (1.A.-)

- ***Estimation Method***

CO and NMVOC emissions from this source were estimated by multiplying the amounts of fuel/raw material burned for each waste type by a Japan-specific emission factor. These emissions are reported in Energy sector (1.A.) following the methodologies given in chapter 7 (Waste).

- ***Emission Factors***

➢ ***CO***

The CO emission factors were established by converting the emission factors (energy unit basis) by furnace type, which are used for estimating emissions from 1A Stationary Sources, to weight-based emission factors by multiplying the calorific values in the *General Energy Statistics*.

Table A 3-67 CO emission factors from incineration in conjunction with use of waste as fuel and raw material

Application	Units	Waste oil	RDF	RPF	Waste tires (FY2004 and before)	Waste tires (FY2005 and after)	Waste plastics	Waste wood
Simple incineration	kg-CO/t	0.13	1.79	1.79	1.79	1.79	-	-
Boilers	kg-CO/t	0.052	0.24	0.39	0.28	0.44	0.034	3.64
Cement kilns	kg-CO/t	49.1	19.8	32.2	23.0	36.5	32.2	-
Other furnaces	kg-CO/t	0.052	0.24	0.39	0.28	0.44	-	-
Pyrolysis furnaces	kg-CO/t	-	-	-	0.021	0.033	-	-
Gasification	kg-CO/t	-	-	-	0.015	0.024	-	-

➢ ***NMVOC***

Just as for the incineration of municipal solid waste and industrial waste, emission factors were determined from documents with estimates of emissions of CH_4 and NMVOCs per unit calorific values.

Table A 3-68 NMVOC emissions factors from incineration in conjunction with use of waste as fuel and raw material

Application	Units	Waste oil	RDF	RPF	Waste tires (FY2004 and before)	Waste tires (FY2005 and after)	Waste plastics	Waste wood
Boilers	kg-NMVOC/t	0.015	0.00027	0.00043	0.00031	0.00049	0.010	0.12
Cement kilns	kg-NMVOC/t	0.048	-	0.043	0.031	0.049	0.043	-
Pyrolysis furnaces	kg-NMVOC/t	-	-	-	0.0051	0.0080	-	-
Gasification	kg-NMVOC/t	-	-	-	0.0089	0.0141	-	-

- ***Activity data***

  Same activity data that were used when estimating CH_4 emissions for the use of waste as fuel and raw material were used.

A3.1.6 Other sectors

A3.1.6.1. Smoking (6.–: CO)

- ***Estimation Method***

  CO emissions were calculated by multiplying the amount of cigarette sales by Japan's country-specific emission factor.

- ***Emission factor***

  The emission factor (0.055 [g-CO/cigarette]) was provided by Japan Tobacco Inc.

- ***Activity data***

  The amount of cigarette sales published on Tobacco Institute of Japan website (http://www.tioj.or.jp/) was used for activity data.

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Annex 4. The National Energy Balance for the Most Recent Inventory Year

A4.1. Discrepancies between the figures reported in the CRF tables and the IEA statistics

In the report of the individual review of the greenhouse gas inventory of Japan submitted in 2006 (FCCC/ARR/2006/JPN), which was conducted from January to February 2007, the ERT (Expert Review Team) recommended that in the next NIR submission Japan provide a clear explanation for the discrepancies found between the data in the CRF tables and the IEA statistics.

In response to this recommendation, Japan has provided the detailed information on the Annex of the NIR regarding the discrepancies of the FY2005 data between the CRF tables and the IEA statistics. Also in the individual review report of the GHG inventory of Japan submitted in 2010 (FCCC/ARR/2010/JPN), the updating of this information with the latest available inventory year data was recommended by the ERT. In response to this recommendation, the detailed information regarding the discrepancies of the reported value between the CRF and the IEA statistics is hereby updated with the FY2013 actual data. The IEA statistical data used in the explanation were extracted from the Energy Statistics of OECD Countries, 2015 Edition, OECD/IEA (CD-ROM version).

In summary, these discrepancies occurred because (a) the CRF tables and the IEA statistics treat international aviation and marine bunker fuels (bonded exports) differently in their respective energy balances and (b) because of the different classifications of fuel oil A. The figures for imports and exports of fuels reported in the CRF tables include the bonded exports, whereas the figures for imports and exports of fuels in the IEA statistics do not. With respect to fuel oil A, Japan includes it under residual fuel oil in its energy balances but reports it to the IEA under gas/diesel oil according to the classifications used in Europe and the United States.

According to Japanese definition, fuel oil A has a flash point of more than 60 °C, kinematic viscosity of below 20 mm^2/s, carbon residue content of below 4% and sulfur content of below 2.0 %. Fuel oil B has a flash point of more than 60 °C, kinematic viscosity of below 50 mm^2/s, carbon residue content of below 8% and sulfur content of below 3.0 %. Fuel oil B is rarely used nowadays in Japan, for this reason, fuel oil B is treated as “fuel oil B/C” together with fuel oil C in Japanese statistics. Fuel oil C has a flash point of more than 70 °C, kinematic viscosity of less than 1,000 mm^2/s and sulfur content of less than 3.5%.

In addition, the preliminary figures of reporting year (y) based on the General Energy Statistics are used for reporting to the IEA in fall of the next fiscal year (y+1), which starts in April and ends in March; on the other hand, the final figures based on the *General Energy Statistics* are used for reporting to the UNFCCC since the final figures are available in the CRF submission period in spring of the next year (y+2). Therefore, there are discrepancies of the reported values between the IEA statistics (preliminary figures) and the CRF tables (final figures) at the time of review under the UNFCCC in summer of the next year (y+2). The preliminary figures reported to the IEA are revised to the final figures in fall of the next year (y+2) and are published in the IEA statistics in summer of the year after next (y+3); the discrepancies between the data in the CRF tables and the IEA statistics are dissolved at the time, except for discrepancies resulted from estimation methods or different classification mentioned above.

Further explanations are provided below for each of the discrepancies noted by the ERT.

a) Differences in exports of jet kerosene and residual fuel oil

<ERT findings on FCCC/ARR/2006/JPN>

Exports of liquid fuels are between 40 and 70 per cent lower in the IEA data; the differences are due in particular to differences in the figures for jet kerosene and residual fuel oil, with the largest errors occurring in recent years.

<Explanation 1: Exports of jet kerosene>

The figures for jet kerosene exports reported in the CRF tables are different from those in the IEA statistics because the CRF figures include bonded exports whereas the export figures in the IEA statistics do not. The IEA statistics accounted the consumption of jet kerosene by international aviation bunkers as an aggregate of the bonded exports and imports. (See Chapter 3, for bonded exports and imports.)

<Reference: Exports of jet kerosene in 2013>

<table>
<tr><td>CRF Table 1.A(b)</td><td>IEA statistics</td></tr>
<tr><td rowspan="2">Exports: 10,456.88×10^3 kl

<Breakdown>
Exports excluding bonded exports: 3,508.20×10^3 kl
Bonded exports: 6,948.68×10^3 kl</td><td>Exports: 2, 748×10^3 t
[3,508.20×10^3 kl (exports excluding bonded exports) × 0.7834 t/kl (density) = 2,748×10^3 t]</td></tr>
<tr><td><Remarks>
International aviation: 6,166×10^3 t
[6,948.68×10^3 kl (bonded exports) + 921.93×10^3 kl (bonded imports) = 7,870.61×10^3 kl;
7,870.61×10^3 kl × 0.7834 t/kl (density)
= 6,166×10^3 t]</td></tr>
</table>

<Explanation 2: Exports of residual fuel oil>

The figures for exports of residual fuel oil reported in the CRF tables are different from those in the IEA statistics because the CRF figures for residual fuel oil include the bonded exports, whereas the export figures for fuel oil in the IEA statistics do not. The bonded exports portion of the fuel oil was reported in the IEA statistics as an aggregate of the bonded exports and imports of fuel oil under international marine bunkers. (See Chapter 3, for bonded exports and imports.)

Further, the figures for exports of residual fuel oil reported in the CRF include fuel oil A, whereas the figures reported under fuel oil in the IEA statistics do not. The IEA reports fuel oil A together with gas oil under gas/diesel oil in its statistics. Because fuel oil A, which is treated as a fuel oil that is distinguished from diesel oil in Japan, is grouped together with diesel oil in Europe and the United States, the fuel oil A data have been included in the diesel oil data in Japan's report to the IEA.

<Reference: Exports of residual fuel oil in 2013>

CRF Table 1.A(b)	IEA statistics
Exports: 6,610.92×10^3 kl [557.88×10^3 kl (fuel oil A) + 6,053.04×10^3 kl (fuel oils B and C) = 6,610.92×10^3 kl] <Breakdown> Exports of fuel oil A: 557.88×10^3 kl Exports excluding bonded exports: 492.56×10^3 kl Bonded exports: 65.02×10^3 kl Exports of fuel oils B and C: 6,053.04×10^3 kl Exports excluding bonded exports: 2,099.77×10^3 kl Bonded exports: 3,953.27×10^3 kl	Exports: 1,890×10^3 t [2,099.77×10^3 kl (exports of fuel oils B and C excluding bonded exports) × 0.9 t/kl (density) = 1,890×10^3 t] <Remarks> International marine bunkers: 3,731×10^3 t [3,953.27×10^3 kl (bonded exports of fuel oils B and C) + 192.70×10^3 kl (bonded imports of fuel oils B and C) = 4,145.97×10^3 kl; 4,145.97×10^3 kl × 0.9 t/kl (density) = 3,731×10^3 t]

b) Differences in imports of jet kerosene and gas/diesel oil

<ERT findings on FCCC/ARR/2006/JPN>

Imports of jet kerosene have been reported to the IEA, but are shown as zero in the CRFs for the years 1990–1997, while imports of gas/diesel oil are systematically about 80 per cent lower in the CRF tables than in the IEA figures.

<Explanation 1: Imports of jet kerosene>

The figures for jet kerosene imports reported in the CRF tables are different from those in the IEA statistics because the CRF figures are the sums of imports including bonded imports and bonded exports while the IEA statistics figures are the imports including bonded imports. (See Chapter 3, for bonded exports and imports.)

<Reference: Jet kerosene imports in 2013>

CRF Table 1.A(b)	IEA statistics
Imports: 7,948.04×10^3 kl <Breakdown > Imports: 7,416.13×10^3 kl Imports excluding bonded imports: 77.44×10^3 kl Bonded imports: 921.93×10^3 kl Bonded exports: 6,948.68×10^3 kl	Imports: 783×10^3 t [77.44×10^3 kl (imports excluding bonded imports) + 921.93×10^3 kl (bonded imports) = 999.37×10^3 kl. 999.37×10^3 kl (imports including bonded imports) × 0.7834 t/kl (density) = 783×10^3 t]

<Explanation 2: Imports of gas/diesel oil>

The figures for imports of gas/diesel oil reported in the CRF tables are different from those in the IEA statistics, because the CRF figures are the sums of imports (including bonded imports) and bonded exports of diesel oil, which excludes fuel oil A, while the figures for imports of gas/diesel oil in the IEA statistics are the aggregate of imports of diesel oil and fuel oil A, both of which included the bonded imports.

<Reference: Imports of gas/diesel oil in 2013>

CRF Table 1.A(b)	IEA statistics
Imports: 507.75×10^3 kl <Imports of gas/diesel oil> Imports excluding bonded imports: 252.72×10^3 kl Bonded imports: 4.81×10^3 kl Bonded exports: 250.22×10^3 kl	Imports: 263×10^3 t [252.72×10^3 kl (imports of gas/diesel oil excluding bonded imports) + 4.81×10^3 kl (bonded imports of gas/diesel oil) + 53.82×10^3 kl (imports of fuel oil A excluding bonded imports) + 0 kl (bonded imports of fuel oil A) = 311.35×10^3 kl; 311.35×10^3 kl × 0.843 t/kl (density) = 263×10^3 t]

c) Differences in imports of coking coal

<ERT findings on FCCC/ARR/2006/JPN>

Furthermore, the figures for imports of coking coal are systematically lower in the CRF tables than those in the IEA statistics, with the largest discrepancy occurring in 1999.

<Explanation: Imports of coking coal>

The imported amounts of coking coal in 2013 reported to IEA were revised. The imported amounts of coking coal in the CRF and the IEA statistics in physical units are the same at this moment.

<Reference: Imports of coking coal in 2013>

CRF Table 1.A(b)	IEA statistics
Imports: $53,852.84\times10^3$ t	Imports: $53,853\times10^3$ t <Remarks> The figures are rounded off in the IEA statistics.

d) Differences in stock changes in liquid and gaseous fuels

<ERT findings on FCCC/ARR/2006/JPN>

In addition, the data on stock changes are not consistent for liquid and gaseous fuels.

It should be noted that the plus-minus signs of stock changes in the CRF differ from those of the IEA. The changes in the CRF are defined as plus for stock increase and as minus for stock release, while the changes in the IEA are defined as minus for stock increase and as plus for stock release.

<Explanation 1: Changes in crude oil stock>

The difference between the CRF table and the IEA statistics with respect to changes in crude oil stock occurred because the figures reported in the CRF were calculated using the stock of crude oil after customs clearance (or more precisely, after inspection in the presence of customs officers). The stock changes reported in the IEA statistics were calculated based on stock that included crude oil carried by oil tankers in Japanese territorial waters but which was yet to clear customs as well as the crude oil in the national stockpile. This discrepancy arose because the UNFCCC and the IEA had different objectives.

<Reference: Changes of crude oil stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -193.60×10^3 kl	Stock changes: 652×10^3 t

<Explanation 2: Changes in NGL stock>

Stock changes concerning NGL in 2013 were reported as zero in the CRF, based on the Mineral Resources and Petroleum Products Statistics. The NGL stock changes reported in the IEA statistics were zero because the NGL stock figure in the Monthly Oil Statistics (MOS) of the IEA was zero. This discrepancy resulted from the direction given by the IEA that the figures in the IEA statistics must be consistent with the MOS figures.

Furthermore, the figures for "stock changes" required by the CRF tables are not included in the MOS. On the other hand, the MOS requires figures for opening stock and closing stock, but Japan does not collect such statistical data for NGL. As a result, Japan reported zero values to the IEA for both opening stock and closing stock data for the MOS. In light of the fact that no statistical data exists for stock changes in NGL, even though the stock actually existed, with respect to the CRF tables the estimated value is reported.

<Explanation 3: Changes in gasoline stock>

The changes in gasoline stock in the CRF correspond to the stock changes in motor gasoline and in white spirit of the IEA statistics. The values relating to the supply and stock of oil in the IEA statistics are changes of gasoline stock plus national stockpile minus other gasoline stock. Other gasoline stock is reported as stock change of white spirit.

<Reference: Changes in gasoline stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: 344.36×10^3 kl The changes in gasoline stock in the CRF correspond to the stock changes in motor gasoline and in white spirit of the IEA statistics. The figures for changes in gasoline stock reported in the CRF tables differ from the figures in the IEA statistics, because the figures in the CRF refer to the monthly report of Mineral Resources and Petroleum Products Statistics, while those in the IEA statistics refer to the annual report of that statistics.	Stock changes in motor gasoline: -158×10^3 t $(254-410-2.10)\times10^3 = -158\times10^3$ Stock changes in motor gasoline: [344.36×10^3 kl × 0.737 t/kl (density) $= 254\times10^3$ t] changes in national stockpile: [-410.20×10^3 kl × 0.737 t/kl (density) = -410×10^3 t] Stock changes in other gasoline: [2.96×10^3 kl × 0.737 t/kl (density) = 2.10×10^3 t] <Reference>Stock changes in white spirit Stock changes in white spirit: -2×10^3 t [-2.96×10^3 kl × 0.737 t/kl (density) = -2.10×10^3 t]

<Explanation 4: Changes in jet kerosene stock>

The figures for changes in jet kerosene stock reported in the CRF tables are basically the same as the figures in the IEA statistics. The figures for the latest reported year in the CRF tables sometimes

slightly differ from the figures in the IEA statistics, because of the difference between preliminary and final figures.

<Reference: Changes in jet kerosene stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: 75.95×10^3 kl	Stock changes: 60×10^3 t [75.95×10^3 kl (preliminary figure) × 0.7834 t/kl (density) = 60×10^3 t] <Remarks> The difference is calculated from the amount which is rounded off to whole after multiplying the stock volume at the end of fiscal year by density. Therefore it sometimes slightly differs from the result which is obtained by multiplying the total changes by density.

<Explanation 5: Changes in kerosene stock>

The figures reported in the CRF tables are changes in kerosene stock only, while the figures in the IEA statistics are the sum of the changes in kerosene stock and national stockpile of kerosene.

<Reference: Changes in kerosene stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: 454.52×10^3 kl	Stock changes: 266×10^3 t [454.52×10^3 kl × 0.814 t/kl (density) =370×10^3 t] Change of national stockpile: -103.49×10^3 kl

<Explanation 6: Changes in gas/diesel oil stock>

The figures for gas/diesel stock reported in the CRF tables were different from those in the IEA statistics because the CRF figures did not include stock changes in fuel oil A and change of national stockpile of gas/diesel oil and fuel oil A while the IEA statistics did.

<Reference: Changes in gas/diesel oil stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -589.54×10^3 kl	Stock changes: 285×10^3 t Stock change of diesel oil 589.54×10^3 kl×0.843 t/kl (density) = 496.98×10^3 t Stock change of fuel oil A 132×10^3 kl×0.843 t/kl (density) =111.28×10^3 t Change of national stockpile of gas/diesel oil -214×10^3 kl Change of national stockpile of fuel oil A -110×10^3 kl

<Explanation 7: Changes in residual fuel oil stock>

The figures for residual fuel oil stock reported in the CRF tables were different from those in the IEA statistics because the CRF figures included changes in fuel oil A stock, whereas stock change data

under fuel oil in the IEA statistics did not include fuel oil A. (See the explanation for the gas/diesel oil data above.)

<Reference: Changes in residual fuel oil stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -274.55×10^3 kl <Breakdown> Stock changes in fuel oil A: -132.48×10^3 kl (final figure) Stock changes in fuel oil C: -142.07×10^3 kl	Stock changes: 128×10^3 t [142.07×10^3 kl (stock changes in fuel oil C) × 0.900 t/kl (density) = 128×10^3 t] <Remark> The difference is calculated from the amount which is rounded off to whole after multiplying the stock volume at the end of fiscal year by density. Therefore it sometimes slightly differs from the result which is obtained by multiplying the total changes by density.

<Explanation 8: Changes in LPG stock>

The figures for changes in LPG stock reported in the CRF tables differ from those reported in IEA statistics, because the LPG stock in IEA includes the national stock. Also, the figures in IEA statistics are derived from MOS (Monthly Oil Statistics),

<Reference: Changes in LPG stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -106.60×10^3 t	Stock changes: 53×10^3 t [-106.60×10^3 t (change of LPG stock) +159×10^3 t (change of national stockpile of LPG) = 53×10^3 t]

<Explanation 9: Changes in naphtha stock>

The figures for changes in naphtha stock reported in the CRF tables are the same as the figures in the IEA statistics. (The figures for the latest reported year in the CRF tables sometimes slightly differ from the figures in the IEA statistics, because of the difference between preliminary and final figures.)

<Reference: Changes in naphtha stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -186.43×10^3 kl	Stock changes: 138×10^3 t [186.43×10^3 kl × 0.737 t/kl (density) = 138×10^3 t]

<Explanation 10: Changes in bitumen stock>

The figures for changes in bitumen stock reported in the CRF tables were slightly different from the figures reported under bitumen in the IEA statistics because the bitumen data in the CRF tables included asphalt and miscellaneous heavy oil products. The IEA statistics reported figures for only asphalt under bitumen, and the figures for miscellaneous heavy oil products reported in the CRF tables under bitumen were included in the figures reported under paraffin waxes in the IEA statistics.

<Reference: Changes in bitumen stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -4.22×10^3 t	Stock changes in bitumen: -2.14×10^3 t
<Breakdown> Asphalt: -2.14×10^3 t Miscellaneous heavy oil products: -2.08×10^3 t	<Remarks> The figures for miscellaneous heavy oil products were reported under bitumen in the CRF tables, while they were reported under paraffin waxes in the IEA statistics.

<Explanation 11: Changes in lubricants stock>

The figures for changes in lubricants stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in lubricants stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: 17.68×10^3 kl	Stock changes: -15×10^3 t [-17.68×10^3 kl × 0.891 t/kl (density) = -15×10^3 t]

<Explanation 12: Changes in petroleum coke stock>

The figures for changes in petroleum coke stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in petroleum coke stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: 1.99×10^3 t	Stock changes: -2×10^3 t <Remarks> In the IEA statistics, the stock changes (or the differences) are calculated after the stock amount is rounded off.

<Explanation 13: Changes in refinery feedstock stock>

The figures for changes in refinery feedstock stock reported in the CRF were different from those in the IEA statistics because the IEA statistics included the figures for stock changes in slack wax and slack coke in addition to the semi-refined products reported in the CRF tables.

The changes in slack wax and coke stocks were not reported in the CRF tables because the both items were solids used as raw materials for the production of paraffin and petroleum coke, and unlikely to be returned to oil refining processes. In addition, shipments of paraffin and petroleum coke produced using slack wax and slack coke were separately accounted for.

The figures for changes in some products stock in the CRF tables sometimes slightly differ from the figures in the IEA statistics in the latest reported year, because of the difference between preliminary and final figures.

<Reference: Changes in refinery feedstock stock in 2013>

CRF Table 1.A(b)		IEA statistics	
Stock changes: 611.33×10^3 kl		Stock changes: 561×10^3 t	
<Breakdown>		<Breakdown>	
Slack gasoline:	-196.68×10^3 kl	Slack gasoline:	-197×10^3 kl
Slack kerosene:	101.17×10^3 kl	Slack kerosene:	101×10^3 kl
Slack diesel oil or gas oil:	245.33×10^3 kl	Slack diesel oil or gas oil:	245×10^3 kl
Slack fuel oil:	412.26×10^3 kl	Slack fuel oil:	412×10^3 kl
Slack lubricant:	49.25×10^3 kl	Slack lubricant:	49×10^3 kl
		Slack wax:	1×10^3 kl
		Slack coke:	2×10^3 kl
		Each of the above figures is multiplied by its density for conversion to weight for reporting purposes.	

<Explanation 14: Changes in natural gas stock>

The figures for changes in natural gas stock (imported LNG and domestic natural gas) reported in the CRF tables were different from those in the IEA statistics mainly because of the differences in the methods used for estimation of changes in the imported LNG stock. Although the source figures for the domestic natural gas stock were the same for reporting of the CRF and the IEA statistics because the statistical data existed in Japan, however the data were estimated for imported LNG because the statistics do not catch whole stocks.

The figures for changes in LNG stock reported in the CRF tables were estimated as the difference between the LNG imports and the consumption. The figures for stock changes reported to the IEA were the difference between the stock of imported LNG at the end of the previous year and the stock at the end of the current year, with the former calculated as one-half of the LNG import in March of the previous year, and the latter as one-half of the LNG import in March of the current year.

<Reference: Changes in natural gas stock in 2013>

CRF Table 1.A(b)	IEA statistics
Stock changes: -132,221 TJ (GCV)	Stock changes: -8,316 TJ (GCV)

A4.2. General Energy Statistics

A4.2.1. General Energy Statistics Overview

The data given in the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy were used for the activity data of fuel combustion in energy sector.

The *General Energy Statistics* (Energy Balance Table) provides a comprehensive overview of domestic energy supply and demand to grasp what are converted from energy sources, such as coal, oil, natural gas and others, provided in Japan and what are consumed in what sectors. The supply/conversion and consumption data in *General Energy Statistics* use official statistics and are structured with the minimum of estimation and adjustment.

General Energy Statistics (Energy Balance Table) indicates an overview of domestic energy supply and demand, shows the main energy sources used in Japan as "Columns" and the supply, conversion and consumption sectors as "Rows", in a matrix. Specifically, columns comprise 11 major categories (coal [$100[1]], coal products [$150], oil [$200], oil products [$250], natural gas [$400], town gas [$450], new and renewable energy [$500], large-scale hydropower [$550], nuclear power [$600], electricity [$700], and heat [$800]) and the necessary sub-categories and a more detailed breakdown of the sub-categories. The *General Energy Statistics* supply and demand sectors (rows) comprise 3 major sectors — primary energy supply (primary supply) [#100000], energy conversion (conversion) [#200000], and final energy consumption (final consumption) [#500000] — plus the necessary sub-categories and a more detailed breakdown of the sub-categories. (Refer to the following *General Energy Statistics* simplified table.)

The *General Energy Statistics* (complete Energy Balance Tables) for the years since FY1990 is available on the following internet site:

http://www.enecho.meti.go.jp/statistics/total_energy/results.html#headline2

The following is the energy balance simplified table (Table A 4-1 – Table A 4-7).

[1] Code number of the *General Energy Statistics* (Energy Balance Table)

Table A 4-1 Energy balance simplified table (General Energy Statistics, FY1990)

1990FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	3,351,970	15,352	9,163,671	2,341,168	2,059,168	0	576,697	809,525	1,884,467	0	0	20,202,018	18,628,558	1,573,460
110000	**Indigenously Produced**	193,762	0	24,484	0	89,203	0	576,697	809,525	1,884,467	0	0	3,578,139	0	0
120000	**Imported**	3,158,208	15,352	9,139,187	2,341,168	1,969,965	0	0	0	0	0	0	16,623,880	0	0
150000	**Total Primary Energy Supply**	3,351,970	15,352	9,163,671	2,341,168	2,059,168	0	576,697	809,525	1,884,467	0	0	20,202,018	18,628,558	1,573,460
160000	**Export**	-53	-56,644	0	-292,955	0	0	0	0	0	0	0	-349,653	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	1,689	1,951	-181,961	-21,786	42,726	0	0	0	0	0	0	-157,381	0	0
190000	**Domestic Primary Energy Supply** (Supply)	3,353,605	-39,341	8,981,710	2,026,426	2,101,894	0	576,697	809,525	1,884,467	0	0	19,694,985	18,121,524	1,573,460
	(Demand)												19,718,055	18,144,594	1,573,460
200000	**Energy Transformation & Own Use**	-3,071,186	1,518,041	-8,961,118	5,215,164	-2,039,611	480,216	-514,440	-809,525	-1,884,467	2,835,828	1,053,095	-6,178,003	-6,116,947	-61,056
210000	**Manufacture of Coal Products** (+: output/-: input)	-2,146,588	2,084,297	0	-27,197	0	0	0	0	0	0	0	-89,488	-89,488	0
220000	**Oil Products** (+: output/-: input)	0	0	-8,072,249	8,114,472	5,121	0	0	0	0	0	-94,149	-46,806	0	-46,806
230000	**Gas Conversion and Production** (+: output/-: input)	0	-19,178	0	-161,220	-503,899	683,704	-546	0	0	0	0	-1,139	-1,139	0
240000	**Power Generation**	-673,045	-204,274	-874,209	-1,052,475	-1,531,705	-65	-14,244	-754,661	-1,883,470	2,698,379	0	-4,289,768	-4,289,768	0
250000	**Auto Power Generation**	-106,472	-96,769	0	-694,049	-4,270	-39,886	-165,575	-54,864	-998	438,848	0	-724,035	-724,035	0
260000	**Auto Steam Generation**	-128,225	-83,794	0	-638,118	-3,476	-135,946	-332,372	0	0	0	1,141,595	-180,336	-180,336	0
270000	**District Heat Supply**	-824	0	0	-2,592	0	-6,169	-1,693	0	0	-1,229	8,464	-4,043	-4,043	0
280000	**Other Energy Transformation**	-2,880	2,880	0	7,541	0	0	0	0	0	0	0	7,541	0	7,541
290000	**Total Energy Transformation**	-3,058,033	1,683,161	-8,946,458	5,546,363	-2,038,231	501,639	-514,430	-809,525	-1,884,467	3,135,998	1,055,910	-5,328,074	-5,288,809	-39,265
300000	**Own Use and Loss**	-3,015	-167,297	-1,017	-330,664	-1,738	-21,423	0	0	0	-300,170	-2,814	-828,138	-828,138	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	-10,138	2,177	-13,642	-534	357	0	-10	0	0	0	0	-21,791	0	-21,791
400000	**Statistical Discrepancy** (+: excess/-: shortage)	-99,280	0	20,592	208,409	1,526	13,164	2,178	-0	0	36,736	-2,469	180,856	112,988	67,868
500000	**Final Energy Consumption**	381,699	1,478,701	0	7,241,871	62,282	480,216	62,258	0	0	2,801,977	1,031,047	13,540,052	12,027,648	1,512,404
600000	**Industry**	381,667	1,475,821	0	3,639,805	62,282	137,224	2,178	0	0	2,080,128	1,029,763	8,808,868	7,337,216	1,471,652
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	537,523	3,313	1,976	0	0	0	60,368	66,998	670,178	427,441	242,737
620000	**Manufacturing**	381,667	1,440,160	0	2,102,746	57,444	55,826	0	0	0	1,494,919	817,178	6,349,940	5,188,892	1,161,047
621000	Manufacture of Food, Beverages, Tobacco and Feed	0	0	0	83,718	0	4,910	0	0	0	93,565	8,574	190,767	190,767	0
622000	Manufacture of Textile Mill Products	0	0	0	38,510	0	1,376	0	0	0	71,030	65,161	176,077	176,077	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	8,127	0	469	0	0	0	25,265	3,971	37,831	37,831	0
624000	Manufacture of Pulp, Paper and Paper Products	126	0	0	32,512	2	1,409	0	0	0	137,683	256,878	428,610	428,610	0
625000	Printing and Allied Industries	0	0	0	2,840	0	845	0	0	0	32,891	881	37,458	37,458	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	5,443	81,393	0	1,407,241	30,006	2,389	0	0	0	224,065	314,805	2,065,343	912,048	1,153,295
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	11,362	0	437	0	0	0	94,747	2,816	109,363	109,363	0
628000	Manufacture of Ceramic, Stone and Clay Products	255,688	37,200	0	199,746	833	6,500	0	0	0	128,445	10,013	638,425	621,842	16,584
629000	Manufacture of Iron and Steel	156,347	1,305,972	0	165,851	25,340	12,008	0	0	0	357,514	102,530	2,125,562	2,124,877	685
630000	Manufacture of Machinery	15	15,595	0	125,111	5,750	26,160	0	0	0	372,188	81,809	626,627	626,627	0
641000	Miscellaneous Manufacturing Industry	0	0	0	4,145	0	65	0	0	0	7,100	591	11,901	11,901	0
649000	Duplication Adjustment for Manufacturing	-35,952	0	0	23,582	-4,487	-742	0	0	0	-49,573	-30,852	-98,025	-88,508	-9,517
650000	**Commercial Industry**	0	35,661	0	999,536	1,526	79,422	2,178	0	0	524,841	145,587	1,788,751	1,720,883	67,868
651000	Electricity, Gas, Heat Supply and Water	0	0	0	12,028	0	302	0	0	0	23,566	1,522	37,417	37,417	0
652000	Information and Communications	0	0	0	3,016	0	1,449	0	0	0	28,877	2,464	35,806	35,806	0
653000	Transport and Postal Activities	0	0	0	110,205	0	612	0	0	0	31,762	2,640	145,219	145,219	0
654000	Wholesale and Retail Trade	0	0	0	146,704	0	3,480	0	0	0	137,320	4,950	292,455	292,455	0
655000	Finance and Insurance	0	0	0	5,162	0	1,947	0	0	0	12,869	8,208	28,185	28,185	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	12,154	0	3,283	0	0	0	12,142	17,226	44,805	44,805	0
657000	Scientific Research, Professional and Technical Services	0	0	0	12,643	0	327	0	0	0	15,232	529	28,731	28,731	0
658000	Accommodations, Eating and Drinking Services	0	0	0	161,929	0	7,628	0	0	0	47,073	41,356	257,986	257,986	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	91,089	0	8,055	0	0	0	67,646	17,797	184,587	184,587	0
660000	Education, Learning Support	0	0	0	54,347	0	17,463	0	0	0	29,930	1,102	102,842	102,842	0
661000	Medical, Health Care and Welfare	0	0	0	84,277	0	11,585	0	0	0	69,131	21,720	186,713	186,713	0
662000	Compound Services	0	0	0	10,765	0	326	0	0	0	6,516	40,522	58,128	58,128	0
663000	Miscellaneous Services	0	35,661	0	69,626	0	8,725	0	0	0	30,911	9,371	154,293	154,293	0
680000	Government	0	0	0	8,877	0	1,078	0	0	0	8,981	698	19,633	19,633	0
690000	Unable to Classify	0	0	0	216,715	1,526	13,164	2,178	0	0	2,885	-24,518	211,950	144,082	67,868
700000	**Residential**	0	2,880	0	612,878	0	342,989	60,079	0	0	662,933	1,284	1,683,044	1,683,044	0
800000	**Transportation**	33	0	0	2,989,189	0	3	0	0	0	58,916	0	3,048,140	3,007,389	40,752
810000	Passenger Transportation	33	0	0	1,494,029	0	1	0	0	0	55,115	0	1,549,176	1,517,375	31,802
811000	Passenger Vehicle	0	0	0	1,256,616	0	1	0	0	0	0	0	1,256,617	1,224,971	31,646
811500	Bus	0	0	0	74,395	0	0	0	0	0	0	0	74,395	74,395	0
812000	Railway Passenger Transport	33	0	0	11,264	0	0	0	0	0	55,115	0	66,411	66,255	156
813000	Water Passenger Transport	0	0	0	64,954	0	0	0	0	0	0	0	64,954	64,954	0
814000	Air Passenger Transport	0	0	0	88,429	0	0	0	0	0	0	0	88,429	88,429	0
850000	Freight	0	0	0	1,495,160	0	3	0	0	0	3,801	0	1,498,964	1,490,014	8,950
851000	Truck and Lorry	0	0	0	1,353,189	0	3	0	0	0	0	0	1,353,192	1,348,560	4,632
852000	Railway Freight Transport	0	0	0	2,638	0	0	0	0	0	3,801	0	6,440	6,271	169
853000	Water Freight Transport	0	0	0	127,471	0	0	0	0	0	0	0	127,471	123,322	4,149
854000	Air Freight Transport	0	0	0	18,256	0	0	0	0	0	0	0	18,256	18,256	0
900000	**Final Energy Consumption**	381,699	1,455,087	0	5,767,122	48,280	480,178	62,258	0	0	2,801,977	1,031,047	12,027,648	12,027,648	0
950000	**Non-energy and Feedstock Use**	0	23,614	0	1,474,749	14,003	38	0	0	0	0	0	1,512,404	0	1,512,404
951000	Industry	0	23,614	0	1,433,998	14,003	38	0	0	0	0	0	1,471,652	0	1,471,652
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	40,752	0	0	0	0	0	0	0	40,752	0	40,752

Table A 4-2 Energy balance simplified table (General Energy Statistics, FY1995)

1995FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	3,736,133	18,016	10,203,959	2,226,330	2,479,453	0	612,228	741,522	2,694,511	0	0	22,712,151	20,922,954	1,789,197
110000	**Indigenously Produced**	153,374	0	32,455	0	95,250	0	612,228	741,522	2,694,511	0	0	4,329,339	0	0
120000	**Imported**	3,582,759	18,016	10,171,504	2,226,330	2,384,203	0	0	0	0	0	0	18,382,812	0	0
150000	**Total Primary Energy Supply**	3,736,133	18,016	10,203,959	2,226,330	2,479,453	0	612,228	741,522	2,694,511	0	0	22,712,151	20,922,954	1,789,197
160000	**Export**	-75	-103,811	0	-717,021	0	0	0	0	0	0	0	-820,907	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	-3,565	-6,113	-37,147	133,156	59,347	0	0	0	0	0	0	145,677	0	0
190000	**Domestic Primary Energy Supply** (Supply)	3,732,493	-91,908	10,166,812	1,642,465	2,538,799	0	612,228	741,522	2,694,511	0	0	22,036,921	20,247,723	1,789,197
	(Demand)												21,910,643	20,121,445	1,789,197
200000	**Energy Transformation & Own Use**	-3,322,198	1,339,447	-10,063,387	6,650,641	-2,475,475	599,746	-557,552	-741,522	-2,694,511	3,236,278	1,081,967	-6,946,565	-6,886,374	-60,190
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,965,001	1,894,436	0	-25,155	0	0	0	0	0	0	0	-95,720	-95,720	0
220000	**Oil Products** (+: output/-: input)	0	0	-9,375,756	9,425,516	5,773	0	0	0	0	0	-103,260	-47,726	-0	-47,726
230000	**Gas Conversion and Production** (+: output/-: input)	0	-12,205	0	-180,538	-723,679	915,060	-37	0	0	0	0	-1,400	-1,400	0
240000	**Power Generation**	-1,072,304	-210,723	-669,401	-835,632	-1,751,588	-663	-28,525	-692,870	-2,692,987	3,080,870	0	-4,873,823	-4,873,823	0
250000	**Auto Power Generation**	-137,750	-107,550	-638	-757,680	-4,896	-75,513	-189,401	-48,652	-1,523	504,389	0	-819,215	-819,215	0
260000	**Auto Steam Generation**	-142,343	-75,717	-570	-647,773	-3,674	-207,831	-335,673	0	0	0	1,172,394	-241,187	-241,187	0
270000	**District Heat Supply**	-638	0	0	-1,601	0	-11,101	-3,934	0	0	-2,548	16,423	-3,398	-3,398	0
280000	**Other Energy Transformation**	-1,637	1,637	0	8,995	0	0	0	0	0	0	0	8,995	0	8,995
290000	**Total Energy Transformation**	-3,319,672	1,489,877	-10,046,364	6,986,132	-2,478,064	619,951	-557,570	-741,522	-2,694,511	3,582,711	1,085,557	-6,073,474	-6,034,743	-38,731
300000	**Own Use and Loss**	-2,978	-143,206	-1,058	-332,899	-1,261	-20,205	0	0	0	-346,434	-3,590	-851,631	-851,631	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	452	-7,224	-15,964	-2,592	3,850	0	19	0	0	0	0	-21,460	0	-21,460
400000	**Statistical Discrepancy** (+: excess/-: shortage)	-37,512	0	103,425	109,949	485	-8,940	1,841	-0	-0	16,130	-1,166	184,213	110,227	73,986
500000	**Final Energy Consumption**	447,806	1,247,539	0	8,293,256	63,325	599,746	54,676	0	0	3,194,155	1,063,574	14,964,078	13,235,071	1,729,007
600000	**Industry**	447,775	1,245,902	0	3,997,779	63,325	200,457	1,877	0	0	2,302,511	1,062,206	9,321,832	7,625,325	1,696,507
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	469,866	1,730	2,563	0	0	0	57,244	73,635	605,038	383,657	221,381
620000	**Manufacturing**	447,775	1,228,568	0	2,440,789	61,109	94,632	36	0	0	1,447,915	779,200	6,500,026	5,098,886	1,401,140
621000	Manufacture of Food, Beverages, Tobacco and Feed	0	0	0	95,156	0	8,334	0	0	0	107,449	12,447	223,387	223,387	0
622000	Manufacture of Textile Mill Products	0	0	0	35,518	14	1,690	0	0	0	65,856	69,069	172,146	172,146	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	7,669	0	617	0	0	0	23,553	4,278	36,117	36,117	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	35,178	5	5,917	36	0	0	137,921	254,113	433,169	433,169	0
625000	Printing and Allied Industries	0	0	0	4,688	0	937	0	0	0	26,357	607	32,589	32,589	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	5,454	64,897	0	1,775,440	28,034	7,771	0	0	0	224,378	283,401	2,389,375	1,000,955	1,388,420
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	12,114	0	484	0	0	0	77,870	1,806	92,275	92,275	0
628000	Manufacture of Ceramic, Stone and Clay Products	256,961	34,623	0	197,965	1,760	7,691	0	0	0	123,872	11,451	634,323	615,783	18,540
629000	Manufacture of Iron and Steel	210,443	1,113,646	0	159,751	26,340	24,583	0	0	0	335,124	101,978	1,971,865	1,971,657	208
630000	Manufacture of Machinery	4	15,402	0	123,195	8,413	46,074	0	0	0	367,550	73,466	634,104	634,104	0
641000	Miscellaneous Manufacturing Industry	0	0	0	3,412	0	87	0	0	0	7,185	420	11,104	11,104	0
649000	Duplication Adjustment for Manufacturing	-25,087	0	0	-9,295	-3,457	-9,553	0	0	0	-49,200	-33,834	-130,426	-124,399	-6,028
650000	**Commercial Industry**	0	17,334	0	1,087,124	485	103,261	1,841	0	0	797,351	209,371	2,216,768	2,142,782	73,986
651000	Electricity, Gas, Heat Supply and Water	0	0	0	12,889	0	280	0	0	0	64,315	1,300	78,784	78,784	0
652000	Information and Communications	0	0	0	3,133	0	1,349	0	0	0	87,934	1,851	94,268	94,268	0
653000	Transport and Postal Activities	0	0	0	111,755	0	559	0	0	0	81,211	2,047	195,573	195,573	0
654000	Wholesale and Retail Trade	0	0	0	138,535	0	6,642	0	0	0	167,104	11,351	323,633	323,633	0
655000	Finance and Insurance	0	0	0	6,124	0	2,032	0	0	0	13,768	8,376	30,301	30,301	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	15,226	0	4,447	0	0	0	15,270	18,018	52,960	52,960	0
657000	Scientific Research, Professional and Technical Services	0	0	0	18,051	0	555	0	0	0	18,912	592	38,111	38,111	0
658000	Accommodations, Eating and Drinking Services	0	0	0	200,688	0	23,855	0	0	0	67,020	46,850	338,413	338,413	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	108,352	0	13,699	0	0	0	89,974	58,017	270,042	270,042	0
660000	Education, Learning Support	0	0	0	60,164	0	20,784	0	0	0	62,646	1,005	144,599	144,599	0
661000	Medical, Health Care and Welfare	0	0	0	124,654	0	20,200	0	0	0	84,059	25,700	254,613	254,613	0
662000	Compound Services	0	0	0	12,653	0	385	0	0	0	8,057	42,487	63,583	63,583	0
663000	Miscellaneous Services	0	17,334	0	73,966	0	15,560	0	0	0	48,933	10,735	166,528	166,528	0
680000	Government	0	0	0	13,022	0	1,854	0	0	0	14,138	600	29,614	29,614	0
690000	Unable to Classify	0	0	0	187,911	485	-8,940	1,841	0	0	-25,992	-19,559	135,747	61,761	73,986
700000	**Residential**	0	1,637	0	722,491	0	399,149	52,798	0	0	827,334	1,368	2,004,777	2,004,777	0
800000	**Transportation**	31	0	0	3,572,986	0	141	0	0	0	64,311	0	3,637,469	3,604,969	32,500
810000	Passenger Transportation	31	0	0	1,932,601	0	20	0	0	0	60,652	0	1,993,303	1,968,416	24,887
811000	Passenger Vehicle	0	0	0	1,661,963	0	1	0	0	0	0	0	1,661,964	1,637,193	24,771
811500	Bus	0	0	0	75,228	0	19	0	0	0	0	0	75,246	75,246	0
812000	Railway Passenger Transport	31	0	0	9,759	0	0	0	0	0	60,652	0	70,441	70,325	116
813000	Water Passenger Transport	0	0	0	76,712	0	0	0	0	0	0	0	76,712	76,712	0
814000	Air Passenger Transport	0	0	0	128,698	0	0	0	0	0	0	0	128,698	128,698	0
850000	Freight	0	0	0	1,640,385	0	121	0	0	0	3,659	0	1,644,166	1,636,553	7,613
851000	Truck and Lorry	0	0	0	1,542,925	0	121	0	0	0	0	0	1,543,046	1,539,066	3,980
852000	Railway Freight Transport	0	0	0	2,400	0	0	0	0	0	3,659	0	6,060	5,947	112
853000	Water Freight Transport	0	0	0	128,716	0	0	0	0	0	0	0	128,716	125,195	3,521
854000	Air Freight Transport	0	0	0	24,397	0	0	0	0	0	0	0	24,397	24,397	0
900000	**Final Energy Consumption**	447,806	1,226,794	0	6,597,030	51,289	599,746	54,676	0	0	3,194,155	1,063,574	13,235,071	13,235,071	0
950000	**Non-energy and Feedstock Use**	0	20,745	0	1,696,226	12,036	0	0	0	0	0	0	1,729,007	0	1,729,007
951000	Industry	0	20,745	0	1,663,726	12,036	0	0	0	0	0	0	1,696,507	0	1,696,507
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	32,500	0	0	0	0	0	0	0	32,500	0	32,500

Table A 4-3 Energy balance simplified table (General Energy Statistics, FY2000)

2000FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	**<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ**	**Coal**	**Coal Products**	**Oil**	**Oil Products**	**Natural Gas**	**Town Gas**	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	**Electricity**	**Heat**	**Total**	**Energy Use Total**	**Non-Energy Use Total**
100000	**Primary Energy Supply**	4,210,710	76,219	9,761,337	2,252,207	3,060,666	0	623,221	756,739	2,859,121	0	0	23,600,220	21,722,619	1,877,601
110000	**Indigenously Produced**	66,683	0	28,034	0	106,340	0	623,221	756,739	2,859,121	0	0	4,440,138	0	0
120000	**Imported**	4,144,027	76,219	9,733,303	2,252,207	2,954,327	0	0	0	0	0	0	19,160,082	0	0
150000	**Total Primary Energy Supply**	4,210,710	76,219	9,761,337	2,252,207	3,060,666	0	623,221	756,739	2,859,121	0	0	23,600,220	21,722,619	1,877,601
160000	**Export**	-112	-78,077	-0	-617,396	0	0	0	0	0	0	0	-695,584	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	-2,972	-1,963	-126,505	-105,883	72,612	0	0	0	0	0	0	-164,711	0	0
190000	**Domestic Primary Energy Supply** (Supply)	4,207,625	-3,821	9,634,832	1,528,928	3,133,278	0	623,221	756,739	2,859,121	0	0	22,739,925	20,862,323	1,877,601
	(Demand)												22,679,037	20,801,436	1,877,601
200000	**Energy Transformation & Own Use**	-3,740,717	1,241,299	-9,622,842	6,921,206	-3,073,049	685,184	-564,904	-756,739	-2,859,121	3,539,549	1,206,286	-7,023,848	-6,920,655	-103,192
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,806,210	1,793,291	0	-28,446	0	0	0	0	0	0	0	-41,365	-41,365	0
220000	**Oil Products** (+: output/-: input)	0	0	-9,331,059	9,414,549	6,972	0	0	0	0	0	-137,327	-46,866	0	-46,866
230000	**Gas Conversion and Production** (+: output/-: input)	0	-9,573	0	-150,046	-925,341	1,084,614	-31	0	0	0	0	-377	-377	0
240000	**Power Generation**	-1,513,154	-212,244	-301,245	-544,697	-2,131,891	-1,632	-27,678	-690,251	-2,852,799	3,333,323	0	-4,942,267	-4,942,267	0
250000	**Auto Power Generation**	-198,490	-157,700	-99	-778,443	-9,548	-111,701	-192,530	-66,488	-6,322	571,104	0	-950,217	-950,217	0
260000	**Auto Steam Generation**	-191,460	-34,306	-119	-620,398	-7,080	-257,626	-339,681	0	0	0	1,324,267	-126,403	-126,403	0
270000	**District Heat Supply**	-708	0	0	-1,692	0	-14,515	-4,963	0	0	-3,940	23,460	-2,358	-2,358	0
280000	**Other Energy Transformation**	0	0	0	-32,978	0	0	0	0	0	0	0	-32,978	0	-32,978
290000	**Total Energy Transformation**	-3,710,022	1,379,469	-9,632,523	7,257,848	-3,066,888	699,140	-564,883	-756,739	-2,859,121	3,900,487	1,210,401	-6,142,831	-6,062,987	-79,844
300000	**Own Use and Loss**	-4,240	-133,158	-518	-340,001	-743	-13,956	0	0	0	-360,938	-4,114	-857,669	-857,669	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	-26,456	-5,012	10,199	3,360	-5,418	0	-21	0	0	0	0	-23,348	0	-23,348
400000	**Statistical Discrepancy** (+: excess/-: shortage)	32,628	0	11,990	-22,459	3,726	15,183	1,032	0	-0	20,006	-7,370	54,737	-15,201	69,938
500000	**Final Energy Consumption**	434,280	1,237,478	0	8,450,162	60,229	685,184	58,317	0	0	3,523,253	1,206,286	15,655,190	13,880,781	1,774,409
600000	**Industry**	434,234	1,237,478	0	3,992,888	60,229	265,212	19,420	0	0	2,529,609	1,204,980	9,744,050	8,003,804	1,740,247
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	385,894	1,930	2,243	0	0	0	48,751	57,372	496,191	315,876	180,315
620000	**Manufacturing**	434,234	1,215,703	0	2,420,791	54,573	85,543	18,388	0	0	1,434,135	878,050	6,541,416	5,051,422	1,489,994
621000	Manufacture of Food, Beverages, Tobacco	0	0	0	108,877	0	10,273	0	0	0	114,082	15,320	248,551	248,551	0
622000	Manufacture of Textile Mill Products	0	0	0	24,842	1	2,362	0	0	0	57,253	69,394	153,852	153,852	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	6,167	0	582	0	0	0	19,855	4,650	31,254	31,254	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	26,741	70	806	12,142	0	0	145,723	261,533	447,014	447,014	0
625000	Printing and Allied Industries	0	0	0	2,540	0	1,376	0	0	0	28,599	645	33,160	33,160	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	19	59,685	0	1,869,898	29,632	6,110	723	0	0	221,220	366,932	2,554,219	1,065,540	1,488,679
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	10,875	0	671	0	0	0	87,345	1,700	100,591	100,591	0
628000	Manufacture of Ceramic, Stone and Clay Products	211,830	24,722	0	166,533	1,682	7,057	6,235	0	0	117,113	15,222	550,394	549,230	1,164
629000	Manufacture of Iron and Steel	234,638	1,122,132	0	140,678	22,413	34,950	19	0	0	346,794	120,154	2,021,777	2,021,625	152
630000	Manufacture of Machinery	0	9,164	0	78,818	945	21,845	2	0	0	328,520	69,414	508,709	508,709	0
641000	Miscellaneous Manufacturing Industry	0	0	0	3,708	0	118	0	0	0	8,400	433	12,659	12,659	0
649000	Duplication Adjustment for Manufacturing	-12,253	0	0	-18,885	-170	-607	-733	0	0	-40,768	-47,347	-120,763	-120,763	-0
650000	**Commercial Industry**	0	21,775	0	1,186,203	3,726	177,425	1,032	0	0	1,046,723	269,558	2,706,444	2,636,506	69,938
651000	Electricity, Gas, Heat Supply and Water	0	0	0	12,668	0	403	0	0	0	47,355	1,408	61,834	61,834	0
652000	Information and Communications	0	0	0	4,870	0	2,633	0	0	0	167,818	2,728	178,049	178,049	0
653000	Transport and Postal Activities	0	0	0	98,481	0	740	0	0	0	59,077	2,308	160,605	160,605	0
654000	Wholesale and Retail Trade	0	0	0	133,595	0	8,085	0	0	0	205,375	12,189	359,243	359,243	0
655000	Finance and Insurance	0	0	0	6,071	0	2,085	0	0	0	13,656	8,406	30,218	30,218	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	18,028	0	5,062	0	0	0	18,067	19,843	60,999	60,999	0
657000	Scientific Research, Professional and Technical Services	0	0	0	22,632	0	1,510	0	0	0	33,338	832	58,311	58,311	0
658000	Accommodations, Eating and Drinking Services	0	0	0	189,717	0	31,910	0	0	0	92,573	60,606	374,805	374,805	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	129,564	0	19,884	0	0	0	105,734	75,279	330,461	330,461	0
660000	Education, Learning Support	0	0	0	67,618	0	27,406	0	0	0	78,638	1,150	174,811	174,811	0
661000	Medical, Health Care and Welfare	0	0	0	174,026	0	35,585	0	0	0	129,491	34,139	373,240	373,240	0
662000	Compound Services	0	0	0	13,152	0	398	0	0	0	8,620	40,882	63,052	63,052	0
663000	Miscellaneous Services	0	21,775	0	92,182	0	23,539	0	0	0	64,869	16,432	218,798	218,798	0
680000	Government	0	0	0	19,020	0	3,002	0	0	0	18,403	728	41,152	41,152	0
690000	Unable to Classify	0	0	0	204,582	3,726	15,183	1,032	0	0	3,710	-7,371	220,864	150,926	69,938
700000	**Residential**	0	0	0	755,073	0	418,832	38,897	0	0	928,274	1,306	2,142,381	2,142,381	0
800000	**Transportation**	46	0	0	3,702,201	0	1,141	0	0	0	65,371	0	3,768,758	3,734,596	34,162
810000	Passenger Transportation	46	0	0	2,165,095	0	172	0	0	0	61,970	0	2,227,282	2,201,535	25,746
811000	Passenger Vehicle	0	0	0	1,927,038	0	20	0	0	0	0	0	1,927,058	1,901,406	25,652
811500	Bus	0	0	0	74,103	0	151	0	0	0	0	0	74,254	74,254	0
812000	Railway Passenger Transport	46	0	0	8,598	0	0	0	0	0	61,970	0	70,613	70,519	94
813000	Water Passenger Transport	0	0	0	76,419	0	0	0	0	0	0	0	76,419	76,419	0
814000	Air Passenger Transport	0	0	0	134,790	0	0	0	0	0	0	0	134,790	134,790	0
850000	Freight	0	0	0	1,537,106	0	969	0	0	0	3,401	0	1,541,477	1,533,061	8,416
851000	Truck and Lorry	0	0	0	1,547,691	0	969	0	0	0	0	0	1,548,661	1,546,050	2,610
852000	Railway Freight Transport	0	0	0	1,878	0	0	0	0	0	3,401	0	5,279	5,196	83
853000	Water Freight Transport	0	0	0	134,452	0	0	0	0	0	0	0	134,452	128,729	5,722
854000	Air Freight Transport	0	0	0	24,246	0	0	0	0	0	0	0	24,246	24,246	0
900000	**Final Energy Consumption**	434,280	1,221,347	0	6,700,409	51,704	685,184	58,317	0	0	3,523,253	1,206,286	13,880,781	13,880,781	0
950000	**Non-energy and Feedstock Use**	0	16,131	0	1,749,753	8,525	0	0	0	0	0	0	1,774,409	0	1,774,409
951000	Industry	0	16,131	0	1,715,590	8,525	0	0	0	0	0	0	1,740,247	0	1,740,247
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	34,162	0	0	0	0	0	0	0	34,162	0	34,162

Table A 4-4 Energy balance simplified table (General Energy Statistics, FY2005)

2005FY	Row $	100	150	200	250	400	450	500	550	600	700	800	900	910	920
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	4,747,650	81,314	9,506,092	2,127,563	3,288,496	0	674,487	667,873	2,661,656	0	0	23,755,132	21,815,779	1,939,353
110000	**Indigenously Produced**	0	0	33,051	0	134,612	0	674,487	667,873	2,661,656	0	0	4,171,679	0	0
120000	**Imported**	4,747,650	81,314	9,473,040	2,127,563	3,153,885	0	0	0	0	0	0	19,583,453	0	0
150000	**Total Primary Energy Supply**	4,747,650	81,314	9,506,092	2,127,563	3,288,496	0	674,487	667,873	2,661,656	0	0	23,755,132	21,815,779	1,939,353
160000	**Export**	-85	-49,279	-4	-880,259	0	0	0	0	0	0	0	-929,626	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	0	-16,228	16,620	-73,470	105,356	0	0	0	0	0	0	32,277	0	0
190000	**Domestic Primary Energy Supply** (Supply)	4,747,565	15,807	9,522,709	1,173,834	3,393,852	0	674,487	667,873	2,661,656	0	0	22,857,783	20,918,430	1,939,353
	(Demand)												22,870,095	20,930,742	1,939,353
200000	**Energy Transformation & Own Use**	-4,376,294	1,284,276	-9,515,826	6,965,350	-3,318,079	800,056	-640,473	-667,873	-2,661,656	3,665,448	1,265,520	-7,199,553	-7,084,486	-115,066
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,829,887	1,798,681	0	-19,638	0	0	0	0	0	0	0	-50,844	-69,777	18,933
220000	**Oil Products** (+: output/-: input)	0	0	-9,209,723	9,277,922	8,203	0	0	0	0	0	-139,784	-63,383	0	-63,383
230000	**Gas Conversion and Production** (+: output/-: input)	0	-1,994	0	-99,300	-1,315,246	1,414,464	-46	0	0	0	0	-2,121	-2,121	0
240000	**Power Generation**	-2,146,038	-186,507	-301,537	-546,903	-1,912,210	-58,869	-69,060	-628,652	-2,661,656	3,454,972	0	-5,056,460	-5,056,460	0
250000	**Auto Power Generation**	-225,239	-143,946	-24	-719,055	-18,052	-153,346	-196,109	-39,221	0	592,463	0	-902,529	-902,529	0
260000	**Auto Steam Generation**	-201,817	-33,452	-33	-544,337	-11,034	-371,980	-369,824	0	0	0	1,383,435	-149,042	-149,042	0
270000	**District Heat Supply**	-633	0	0	-1,023	0	-18,102	-5,322	0	0	-4,129	26,185	-3,024	-3,024	0
280000	**Other Energy Transformation**	0	0	0	-53,958	0	0	0	0	0	0	0	-53,958	0	-53,958
290000	**Total Energy Transformation**	-4,403,614	1,432,781	-9,511,317	7,293,710	-3,248,339	812,167	-640,361	-667,873	-2,661,656	4,043,306	1,269,836	-6,281,362	-6,182,954	-98,408
300000	**Own Use and Loss**	-6,994	-130,127	-85	-328,305	-41,736	-12,111	0	0	0	-377,858	-4,316	-901,532	-901,532	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	34,314	-18,378	-4,424	-55	-28,004	0	-112	0	0	0	0	-16,658	0	-16,658
400000	**Statistical Discrepancy** (+: excess/-: shortage)	-44,031	0	6,882	208,352	10,108	1,940	846	0	0	33,132	30,565	247,794	184,153	63,641
500000	**Final Energy Consumption**	415,301	1,300,083	0	8,139,184	75,773	800,056	34,014	0	0	3,640,612	1,265,520	15,670,543	13,846,256	1,824,287
600000	**Industry**	415,264	1,300,083	0	3,954,181	75,773	360,057	7,175	0	0	2,552,918	1,264,194	9,929,645	8,139,520	1,790,124
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	296,215	2,758	2,316	0	0	0	38,958	4,907	345,153	221,533	123,620
620000	**Manufacturing**	415,264	1,287,950	0	2,404,955	62,907	127,279	6,329	0	0	1,361,785	950,672	6,617,142	5,014,279	1,602,864
621000	Manufacture of Food, Beverages, Tobacco and Feed	0	376	0	102,856	0	15,344	0	0	0	106,206	10,656	235,437	235,437	0
622000	Manufacture of Textile Mill Products	0	0	0	19,746	0	2,562	0	0	0	43,141	53,853	119,302	119,302	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	6,560	0	960	0	0	0	14,950	2,931	25,401	25,401	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	24,100	119	1,062	25	0	0	135,311	253,088	413,705	413,705	0
625000	Printing and Allied Industries	0	0	0	2,367	0	1,591	0	0	0	20,243	1,636	25,837	25,837	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	4,351	66,378	0	1,934,684	31,475	9,291	583	0	0	204,736	503,577	2,755,076	1,152,750	1,602,326
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	10,157	0	806	0	0	0	76,340	4,522	91,825	91,825	0
628000	Manufacture of Ceramic, Stone and Clay Products	179,978	21,910	0	132,223	2,544	10,163	6,300	0	0	101,650	12,037	466,804	463,908	2,896
629000	Manufacture of Iron and Steel	255,413	1,191,401	0	122,297	26,259	53,688	0	0	0	352,153	123,288	2,124,498	2,124,368	130
630000	Manufacture of Machinery	1	7,885	0	62,767	3,007	32,344	5	0	0	333,083	20,367	459,459	459,459	0
641000	Miscellaneous Manufacturing Industry	0	0	0	2,517	0	218	0	0	0	7,715	149	10,599	10,599	0
649000	Duplication Adjustment for Manufacturing	-24,479	0	0	-15,319	-496	-750	-583	0	0	-33,744	-35,431	-110,802	-108,314	-2,488
650000	**Commercial Industry**	0	12,133	0	1,253,011	10,108	230,462	846	0	0	1,152,175	308,615	2,967,349	2,903,708	63,641
651000	Electricity, Gas, Heat Supply and Water	0	0	0	11,165	0	521	0	0	0	44,826	1,328	57,840	57,840	0
652000	Information and Communications	0	0	0	3,947	0	4,268	0	0	0	118,328	2,672	129,215	129,215	0
653000	Transport and Postal Activities	0	0	0	100,615	0	1,042	0	0	0	59,803	2,189	163,649	163,649	0
654000	Wholesale and Retail Trade	0	0	0	142,524	0	36,391	0	0	0	367,277	10,527	556,719	556,719	0
655000	Finance and Insurance	0	0	0	3,293	0	1,862	0	0	0	13,050	8,605	26,809	26,809	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	15,569	0	5,104	0	0	0	19,368	18,860	58,900	58,900	0
657000	Scientific Research, Professional and Technical Services	0	0	0	18,754	0	2,782	0	0	0	26,503	762	48,802	48,802	0
658000	Accommodations, Eating and Drinking Services	0	0	0	172,780	0	35,626	0	0	0	98,793	33,873	341,073	341,073	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	140,814	0	21,650	0	0	0	77,269	82,396	322,130	322,130	0
660000	Education, Learning Support	0	0	0	67,340	0	41,660	0	0	0	72,322	1,080	182,402	182,402	0
661000	Medical, Health Care and Welfare	0	0	0	169,496	0	39,634	0	0	0	93,360	42,662	345,152	345,152	0
662000	Compound Services	0	0	0	8,770	0	397	0	0	0	8,501	33,315	50,983	50,983	0
663000	Miscellaneous Services	0	12,133	0	81,912	0	31,556	0	0	0	121,618	39,198	286,416	286,416	0
680000	Government	0	0	0	24,725	0	6,030	0	0	0	22,860	582	54,197	54,197	0
690000	Unable to Classify	0	0	0	291,308	10,108	1,940	846	0	0	8,296	30,565	343,061	279,421	63,641
700000	**Residential**	0	0	0	721,576	0	436,024	26,839	0	0	1,019,088	1,326	2,204,853	2,204,853	0
800000	**Transportation**	37	0	0	3,463,427	0	3,974	0	0	0	68,607	0	3,536,045	3,501,883	34,162
810000	Passenger Transportation	37	0	0	2,052,402	0	591	0	0	0	65,029	0	2,118,058	2,092,313	25,746
811000	Passenger Vehicle	0	0	0	1,786,274	0	68	0	0	0	0	0	1,786,342	1,760,690	25,652
811500	Bus	0	0	0	68,990	0	523	0	0	0	0	0	69,513	69,513	0
812000	Railway Passenger Transport	37	0	0	7,833	0	0	0	0	0	65,029	0	72,899	72,805	94
813000	Water Passenger Transport	0	0	0	68,179	0	0	0	0	0	0	0	68,179	68,179	0
814000	Air Passenger Transport	0	0	0	137,208	0	0	0	0	0	0	0	137,208	137,208	0
850000	Freight	0	0	0	1,411,025	0	3,383	0	0	0	3,578	0	1,417,987	1,409,570	8,417
851000	Truck and Lorry	0	0	0	1,337,459	0	3,383	0	0	0	0	0	1,340,843	1,338,232	2,610
852000	Railway Freight Transport	0	0	0	1,718	0	0	0	0	0	3,578	0	5,296	5,212	84
853000	Water Freight Transport	0	0	0	115,080	0	0	0	0	0	0	0	115,080	109,358	5,722
854000	Air Freight Transport	0	0	0	23,641	0	0	0	0	0	0	0	23,641	23,641	0
900000	**Final Energy Consumption**	415,301	1,284,271	0	6,346,976	59,507	800,056	34,014	0	0	3,640,612	1,265,520	13,846,256	13,846,256	0
950000	**Non-energy and Feedstock Use**	0	15,812	0	1,792,208	16,266	0	0	0	0	0	0	1,824,287	0	1,824,287
951000	Industry	0	15,812	0	1,758,046	16,266	0	0	0	0	0	0	1,790,124	0	1,790,124
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	34,162	0	0	0	0	0	0	0	34,162	0	34,162

Table A 4-5 Energy balance simplified table (General Energy Statistics, FY2010)

2010FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	4,967,481	29,909	8,161,965	1,926,065	4,001,721	0	944,484	703,039	2,464,843	0	0	23,199,506	21,377,443	1,822,063
110000	**Indigenously Produced**	0	0	30,637	0	149,324	0	944,484	703,039	2,464,843	0	0	4,292,327	0	0
120000	**Imported**	4,967,481	29,909	8,131,328	1,926,065	3,852,397	0	0	0	0	0	0	18,907,179	0	0
150000	**Total Primary Energy Supply**	4,967,481	29,909	8,161,965	1,926,065	4,001,721	0	944,484	703,039	2,464,843	0	0	23,199,506	21,377,443	1,822,063
160000	**Export**	-87	-19,695	0	-1,196,364	0	0	0	0	0	0	0	-1,216,146	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	0	3,901	-43,851	-28,216	241,920	0	0	0	0	0	0	173,755	0	0
190000	**Domestic Primary Energy Supply** (Supply)	4,967,395	14,115	8,118,114	701,484	4,243,641	0	944,484	703,039	2,464,843	0	0	22,157,115	20,335,052	1,822,063
	(Demand)												21,978,772	20,156,708	1,822,063
200000	**Energy Transformation & Own Use**	-4,374,747	1,163,676	-8,133,969	6,454,175	-4,183,666	1,005,071	-915,837	-703,039	-2,464,843	3,703,823	1,168,563	-7,280,793	-7,195,895	-84,898
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,799,858	1,800,147	0	-22,829	0	0	-87	0	0	0	0	-22,626	-44,428	21,802
220000	**Oil Products** (+: output/-: input)	0	0	-7,949,128	8,060,379	5,579	0	0	0	0	0	-146,978	-30,147	0	-30,147
230000	**Gas Conversion and Production** (+: output/-: input)	0	0	0	-67,843	-1,668,358	1,716,444	0	0	0	0	0	-19,757	-19,757	0
240000	**Power Generation**	-2,084,699	-200,982	-189,297	-374,291	-2,349,422	-59,859	-133,227	-658,622	-2,464,843	3,554,113	0	-4,961,127	-4,961,127	0
250000	**Auto Power Generation**	-229,502	-133,767	-59	-313,990	-31,321	-279,716	-289,198	-44,418	0	529,323	0	-792,648	-792,648	0
260000	**Auto Steam Generation**	-209,762	-37,780	-77	-442,209	-23,080	-302,055	-488,046	0	0	0	1,295,847	-207,162	-207,162	0
270000	**District Heat Supply**	0	0	0	-822	0	-17,003	-4,539	0	0	-4,126	25,637	-853	-853	0
280000	**Other Energy Transformation**	0	0	0	-45,756	0	0	0	0	0	0	0	-45,756	0	-45,756
290000	**Total Energy Transformation**	-4,323,822	1,427,618	-8,138,561	6,792,641	-4,066,602	1,057,811	-915,096	-703,039	-2,464,843	4,079,310	1,174,506	-6,080,077	-6,025,976	-54,101
300000	**Own Use and Loss**	-21,642	-266,476	-62	-328,930	-118,640	-52,740	0	0	0	-375,486	-5,943	-1,169,919	-1,169,919	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	-29,283	2,534	4,654	-9,536	1,576	0	-742	0	0	0	0	-30,797	0	-30,797
400000	**Statistical Discrepancy** (+: excess/-: shortage)	202,573	0	-15,855	76,348	-6,392	20,864	767	-0	0	-61,011	20,236	237,529	183,831	53,699
500000	**Final Energy Consumption**	390,075	1,177,791	0	7,155,659	66,367	1,005,071	28,646	0	0	3,705,801	1,168,569	14,697,979	12,960,813	1,737,165
600000	**Industry**	390,032	1,177,791	0	3,316,194	66,367	573,434	8,411	0	0	2,539,298	1,167,286	9,238,813	7,535,810	1,703,003
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	246,149	5,064	2,050	0	0	0	48,502	39	301,804	209,266	92,538
620000	**Manufacturing**	387,733	1,172,442	0	2,237,766	61,303	292,959	7,645	0	0	1,212,751	1,007,964	6,380,563	4,823,796	1,556,767
621000	Manufacture of Food, Beverages, Tobacco and Feed	5,577	350	0	79,175	0	49,440	0	0	0	102,963	15,230	252,733	252,733	0
622000	Manufacture of Textile Mill Products	153	0	0	39,909	0	17,941	0	0	0	41,843	40,106	139,951	139,951	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	4,703	0	1,771	0	0	0	14,295	1,639	22,408	22,408	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	24,716	334	21,751	433	0	0	118,992	218,578	384,804	384,804	0
625000	Printing and Allied Industries	0	0	0	1,314	0	5,157	0	0	0	17,259	533	24,262	24,262	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	16	84,267	0	1,841,456	33,223	15,622	251	0	0	188,653	609,254	2,772,743	1,217,881	1,554,861
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	18,255	0	7,001	0	0	0	66,162	3,141	94,559	94,559	0
628000	Manufacture of Ceramic, Stone and Clay Products	137,864	21,114	0	102,804	4,263	30,828	6,594	0	0	89,497	16,583	409,549	406,432	3,117
629000	Manufacture of Iron and Steel	259,858	1,058,366	0	102,636	20,743	94,911	525	0	0	324,811	125,220	1,987,069	1,986,881	188
630000	Manufacture of Machinery	154	8,344	0	37,698	2,604	51,839	0	0	0	276,448	17,536	394,623	394,623	0
641000	Miscellaneous Manufacturing Industry	0	0	0	2,122	0	682	0	0	0	8,134	21	10,959	10,959	0
649000	Duplication Adjustment for Manufacturing	-15,889	0	0	-17,022	136	-3,984	-159	0	0	-36,304	-39,876	-113,097	-111,698	-1,399
650000	**Commercial Industry**	2,299	5,349	0	832,279	0	278,424	767	0	0	1,278,045	159,284	2,556,447	2,502,748	53,699
651000	Electricity, Gas, Heat Supply and Water	0	0	0	1,552	0	4,775	0	0	0	84,608	457	91,393	91,393	0
652000	Information and Communications	0	0	0	3,814	0	2,947	0	0	0	103,173	7,635	117,569	117,569	0
653000	Transport and Postal Activities	0	0	0	78,369	0	2,088	0	0	0	64,554	526	145,537	145,537	0
654000	Wholesale and Retail Trade	0	0	0	82,432	0	35,168	0	0	0	355,442	5,323	478,366	478,366	0
655000	Finance and Insurance	0	0	0	2,856	0	2,493	0	0	0	15,288	191	20,828	20,828	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	23,243	0	2,607	0	0	0	29,576	63,881	119,306	119,306	0
657000	Scientific Research, Professional and Technical Services	0	0	0	8,292	0	9,348	0	0	0	33,961	463	52,064	52,064	0
658000	Accommodations, Eating and Drinking Services	2,299	2,299	0	118,210	0	40,290	0	0	0	183,844	3,790	350,732	350,732	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	98,557	0	43,501	0	0	0	115,577	50,612	308,248	308,248	0
660000	Education, Learning Support	0	0	0	38,645	0	35,787	0	0	0	81,931	333	156,696	156,696	0
661000	Medical, Health Care and Welfare	0	0	0	119,885	0	61,822	0	0	0	112,766	1,626	296,098	296,098	0
662000	Compound Services	0	0	0	4,025	0	558	0	0	0	4,236	0	8,819	8,819	0
663000	Miscellaneous Services	0	3,051	0	63,757	0	8,924	0	0	0	130,365	3,351	209,448	209,448	0
680000	Government	0	0	0	18,078	0	7,250	0	0	0	21,757	854	47,938	47,938	0
690000	Unable to Classify	0	0	0	170,566	0	20,864	767	0	0	-59,034	20,241	153,404	99,705	53,699
700000	**Residential**	0	0	0	626,460	0	426,970	20,235	0	0	1,098,953	1,282	2,173,901	2,173,901	0
800000	**Transportation**	43	0	0	3,213,005	0	4,667	0	0	0	67,549	0	3,285,265	3,251,102	34,162
810000	Passenger Transportation	43	0	0	1,940,281	0	640	0	0	0	64,349	0	2,005,314	1,979,563	25,751
811000	Passenger Vehicle	0	0	0	1,715,493	0	70	0	0	0	0	0	1,715,562	1,689,910	25,652
811500	Bus	0	0	0	66,118	0	571	0	0	0	0	0	66,688	66,688	0
812000	Railway Passenger Transport	43	0	0	7,025	0	0	0	0	0	64,349	0	71,417	71,319	99
813000	Water Passenger Transport	0	0	0	49,220	0	0	0	0	0	0	0	49,220	49,220	0
814000	Air Passenger Transport	0	0	0	115,381	0	0	0	0	0	0	0	115,381	115,381	0
850000	Freight	0	0	0	1,272,724	0	4,027	0	0	0	3,200	0	1,279,951	1,271,539	8,411
851000	Truck and Lorry	0	0	0	1,227,498	0	4,027	0	0	0	0	0	1,231,525	1,228,915	2,610
852000	Railway Freight Transport	0	0	0	1,449	0	0	0	0	0	3,200	0	4,649	4,570	79
853000	Water Freight Transport	0	0	0	103,490	0	0	0	0	0	0	0	103,490	97,768	5,722
854000	Air Freight Transport	0	0	0	21,548	0	0	0	0	0	0	0	21,548	21,548	0
900000	**Final Energy Consumption**	390,075	1,161,869	0	5,451,926	48,856	1,005,071	28,646	0	0	3,705,801	1,168,569	12,960,813	12,960,813	0
950000	**Non-energy and Feedstock Use**	0	15,922	0	1,703,733	17,511	0	0	0	0	0	0	1,737,165	0	1,737,165
951000	Industry	0	15,922	0	1,669,570	17,511	0	0	0	0	0	0	1,703,003	0	1,703,003
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	34,162	0	0	0	0	0	0	0	34,162	0	34,162

Table A 4-6 Energy balance simplified table (General Energy Statistics, FY2013)

2013FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	5,249,519	64,217	8,028,945	2,016,385	4,953,467	0	915,704	671,323	80,002	0	0	21,979,561	20,313,165	1,666,397
110000	**Indigenously Produced**	0	0	24,164	0	128,831	0	915,704	671,323	80,002	0	0	1,820,023	0	0
120000	**Imported**	5,249,519	64,217	8,004,781	2,016,385	4,824,636	0	0	0	0	0	0	20,159,538	0	0
150000	**Total Primary Energy Supply**	5,249,519	64,217	8,028,945	2,016,385	4,953,467	0	915,704	671,323	80,002	0	0	21,979,561	20,313,165	1,666,397
160000	**Export**	-56	-35,736	0	-1,172,264	0	0	0	0	0	0	0	-1,208,057	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	0	-383	6,143	101,750	132,222	0	0	0	0	0	0	239,733	0	0
190000	**Domestic Primary Energy Supply** (Supply)	5,249,463	28,097	8,035,088	945,871	5,085,690	0	915,704	671,323	80,002	0	0	21,011,237	19,344,841	1,666,397
	(Demand)												21,000,900	19,334,504	1,666,397
200000	**Energy Transformation & Own Use**	-4,688,618	1,116,784	-8,069,174	5,939,260	-5,039,361	1,067,940	-869,024	-671,323	-80,002	3,402,053	899,642	-6,991,822	-6,952,396	-39,427
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,724,901	1,730,083	0	-20,706	0	0	-6,231	0	0	0	0	-21,755	-41,642	19,887
220000	**Oil Products** (+: output/-: input)	0	0	-7,629,016	7,690,806	5,446	0	0	0	0	0	-131,593	-64,357	-0	-64,357
230000	**Gas Conversion and Production** (+: output/-: input)	0	0	0	-74,127	-1,661,654	1,703,900	0	0	0	0	0	-31,881	-31,881	0
240000	**Power Generation**	-2,433,680	-194,820	-454,903	-672,964	-3,180,740	-77,387	-176,803	-627,513	-80,002	3,265,252	0	-4,633,559	-4,633,559	0
250000	**Auto Power Generation**	-254,179	-136,184	-53	-311,335	-31,791	-228,575	-311,236	-43,810	0	498,210	0	-818,954	-818,954	0
260000	**Auto Steam Generation**	-213,954	-41,414	-66	-368,173	-22,224	-265,307	-370,482	0	0	0	1,012,272	-269,349	-269,349	0
270000	**District Heat Supply**	0	0	0	-90	0	-15,929	-3,908	0	0	-3,878	23,900	94	94	0
280000	**Other Energy Transformation**	0	0	0	15,513	0	0	0	0	0	0	0	15,513	0	15,513
290000	**Total Energy Transformation**	-4,626,714	1,357,665	-8,084,038	6,258,924	-4,890,964	1,116,702	-868,661	-671,323	-80,002	3,759,584	904,579	-5,824,247	-5,795,290	-28,956
300000	**Own Use and Loss**	-23,630	-238,681	-470	-345,052	-138,042	-48,762	0	0	0	-357,531	-4,938	-1,157,105	-1,157,105	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	-38,275	-2,200	15,334	25,388	-10,355	0	-363	0	0	0	0	-10,471	0	-10,471
400000	**Statistical Discrepancy** (+: excess/-: shortage)	98,484	-0	-34,086	-11,260	-23,751	11,472	1,037	-0	0	-141,631	13,898	-85,835	-128,915	43,080
500000	**Final Energy Consumption**	462,360	1,144,882	0	6,837,724	70,080	1,067,940	46,680	0	0	3,479,772	899,640	14,009,078	12,382,108	1,626,970
600000	**Industry**	462,321	1,144,882	0	3,113,085	70,080	654,308	29,930	0	0	2,388,825	898,470	8,761,899	7,169,092	1,592,808
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	231,887	5,532	1,944	0	0	0	41,420	64	280,847	202,061	78,786
620000	**Manufacturing**	462,321	1,121,558	0	2,134,547	64,547	325,679	28,892	0	0	1,083,056	729,456	5,950,056	4,479,115	1,470,942
621000	Manufacture of Food, Beverages, Tobacco and Feed	0	270	0	46,306	0	55,585	0	0	0	84,679	27,195	214,034	214,034	0
622000	Manufacture of Textile Mill Products	0	0	0	25,759	0	17,963	0	0	0	32,582	42,533	118,837	118,837	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	5,548	0	2,425	0	0	0	12,484	1,197	21,655	21,655	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	19,100	555	12,739	745	0	0	110,386	196,329	339,855	339,855	0
625000	Printing and Allied Industries	0	0	0	2,768	0	5,577	0	0	0	15,114	232	23,691	23,691	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	24	77,775	0	1,781,481	32,600	25,645	1,394	0	0	166,409	334,100	2,419,428	953,370	1,466,057
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	14,453	0	14,098	0	0	0	51,387	4,577	84,515	84,515	0
628000	Manufacture of Ceramic, Stone and Clay Products	180,344	20,520	0	126,711	4,250	38,358	17,792	0	0	82,441	15,211	485,628	481,313	4,315
629000	Manufacture of Iron and Steel	302,310	1,016,033	0	90,296	23,984	105,197	2,580	0	0	318,279	120,513	1,979,192	1,979,104	88
630000	Manufacture of Machinery	0	6,959	0	32,005	2,902	50,167	0	0	0	233,805	20,015	345,854	345,854	0
641000	Miscellaneous Manufacturing Industry	0	0	0	4,860	0	619	0	0	0	7,122	45	12,646	12,646	0
649000	Duplication Adjustment for Manufacturing	-20,357	0	0	-14,740	255	-2,694	6,381	0	0	-31,633	-32,490	-95,278	-95,759	481
650000	**Commercial Industry**	0	23,324	0	746,651	0	326,685	1,037	0	0	1,264,349	168,950	2,530,995	2,487,916	43,080
651000	Electricity, Gas, Heat Supply and Water	0	0	0	2,107	0	925	0	0	0	64,532	465	68,029	68,029	0
652000	Information and Communications	0	0	0	2,298	0	6,345	0	0	0	124,574	577	133,793	133,793	0
653000	Transport and Postal Activities	0	0	0	64,805	0	3,101	0	0	0	52,444	300	120,650	120,650	0
654000	Wholesale and Retail Trade	0	0	0	98,957	0	27,084	0	0	0	338,340	180	464,560	464,560	0
655000	Finance and Insurance	0	0	0	2,746	0	2,501	0	0	0	13,349	132	18,729	18,729	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	31,892	0	5,568	0	0	0	32,161	144,609	214,230	214,230	0
657000	Scientific Research, Professional and Technical Services	0	0	0	8,922	0	10,506	0	0	0	26,796	272	46,496	46,496	0
658000	Accommodations, Eating and Drinking Services	0	0	0	179,538	0	71,147	0	0	0	195,601	1,072	447,359	447,359	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	121,985	0	63,956	0	0	0	124,701	2,617	313,259	313,259	0
660000	Education, Learning Support	0	0	0	40,331	0	37,827	0	0	0	78,322	206	156,686	156,686	0
661000	Medical, Health Care and Welfare	0	0	0	117,152	0	60,122	0	0	0	104,690	1,604	283,569	283,569	0
662000	Compound Services	0	0	0	1,849	0	73	0	0	0	3,003	0	4,925	4,925	0
663000	Miscellaneous Services	0	23,324	0	65,157	0	19,782	0	0	0	154,134	2,764	265,161	265,161	0
680000	Government	0	0	0	21,611	0	6,275	0	0	0	15,613	253	43,753	43,753	0
690000	Unable to Classify	0	0	0	-12,700	0	11,472	1,037	0	0	-63,911	13,896	-50,205	-93,285	43,080
700000	**Residential**	0	0	0	557,951	0	409,674	16,750	0	0	1,026,648	1,170	2,012,193	2,012,193	0
800000	**Transportation**	39	0	0	3,166,688	0	3,958	0	0	0	64,299	0	3,234,985	3,200,823	34,162
810000	Passenger Transportation	39	0	0	1,914,131	0	544	0	0	0	61,205	0	1,975,918	1,950,166	25,752
811000	Passenger Vehicle	0	0	0	1,706,448	0	43	0	0	0	0	0	1,706,491	1,680,839	25,652
811500	Bus	0	0	0	63,870	0	500	0	0	0	0	0	64,370	64,370	0
812000	Railway Passenger Transport	39	0	0	6,618	0	0	0	0	0	61,205	0	67,862	67,762	100
813000	Water Passenger Transport	0	0	0	48,728	0	0	0	0	0	0	0	48,728	48,728	0
814000	Air Passenger Transport	0	0	0	126,727	0	0	0	0	0	0	0	126,727	126,727	0
850000	Freight	0	0	0	1,252,557	0	3,415	0	0	0	3,095	0	1,259,067	1,250,656	8,411
851000	Truck and Lorry	0	0	0	1,133,364	0	3,415	0	0	0	0	0	1,136,779	1,134,168	2,610
852000	Railway Freight Transport	0	0	0	1,339	0	0	0	0	0	3,095	0	4,434	4,356	78
853000	Water Freight Transport	0	0	0	103,472	0	0	0	0	0	0	0	103,472	97,750	5,722
854000	Air Freight Transport	0	0	0	22,088	0	0	0	0	0	0	0	22,088	22,088	0
900000	**Final Energy Consumption**	462,360	1,127,968	0	5,246,679	51,068	1,067,940	46,680	0	0	3,479,772	899,640	12,382,108	12,382,108	0
950000	**Non-energy and Feedstock Use**	0	16,914	0	1,591,045	19,011	0	0	0	0	0	0	1,626,970	0	1,626,970
951000	Industry	0	16,914	0	1,556,883	19,011	0	0	0	0	0	0	1,592,808	0	1,592,808
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	34,162	0	0	0	0	0	0	0	34,162	0	34,162

Table A 4-7 Energy balance simplified table (General Energy Statistics, FY2014)

2014FY	*Row $*	*100*	*150*	*200*	*250*	*400*	*450*	*500*	*550*	*600*	*700*	*800*	*900*	*910*	*920*
Line #	<< General Energy Statistics >> Simplified energy unit table GCV (gross calorific value) basis Display unit: TJ	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	Renewable and Recovered Energy	Large Scale Hydraulic Power Generation	Nuclear Power Generation	Electricity	Heat	Total	Energy Use Total	Non-Energy Use Total
100000	**Primary Energy Supply**	5,034,349	98,353	7,413,459	1,974,550	4,963,102	0	881,505	690,638	0	0	0	21,055,955	19,496,028	1,559,927
110000	**Indigenously Produced**	0	0	22,464	0	111,847	0	881,505	690,638	0	0	0	1,706,453	0	0
120000	**Imported**	5,034,349	98,353	7,390,995	1,974,550	4,851,255	0	0	0	0	0	0	19,349,501	0	0
150000	**Total Primary Energy Supply**	5,034,349	98,353	7,413,459	1,974,550	4,963,102	0	881,505	690,638	0	0	0	21,055,955	19,496,028	1,559,927
160000	**Export**	-33	-14,802	-2	-1,106,011	0	0	0	0	0	0	0	-1,120,847	0	0
170000	**Stockpile Change / Supply** (+: withdrawal/-: build-up)	0	-1,238	-17,289	41,777	100,359	0	0	0	0	0	0	123,609	0	0
190000	**Domestic Primary Energy Supply** (Supply)	5,034,317	82,313	7,396,168	910,316	5,063,461	0	881,505	690,638	0	0	0	20,058,716	18,498,790	1,559,927
	(Demand)												20,051,047	18,491,121	1,559,927
200000	**Energy Transformation & Own Use**	-4,545,863	1,092,497	-7,428,802	5,711,985	-5,045,098	1,125,792	-836,382	-690,638	0	3,377,008	746,867	-6,492,634	-6,531,957	39,323
210000	**Manufacture of Coal Products** (+: output/-: input)	-1,668,364	1,688,759	0	-24,895	0	0	-5,265	0	0	0	0	-9,764	-29,413	19,649
220000	**Oil Products** (+: output/-: input)	0	0	-7,158,118	7,182,731	5,258	0	0	0	0	0	-119,373	-89,503	0	-89,503
230000	**Gas Conversion and Production** (+: output/-: input)	0	0	0	-77,471	-1,681,709	1,747,302	0	0	0	0	0	-11,878	-11,878	0
240000	**Power Generation**	-2,395,182	-193,688	-265,798	-495,344	-3,169,108	-125,006	-196,213	-646,823	0	3,163,126	0	-4,324,035	-4,324,035	0
250000	**Auto Power Generation**	-301,225	-129,310	-46	-346,581	-30,875	-259,113	-312,875	-43,815	0	558,548	0	-865,290	-865,290	0
260000	**Auto Steam Generation**	-215,273	-36,270	-58	-297,305	-21,731	-171,677	-317,961	0	0	0	848,552	-211,722	-211,722	0
270000	**District Heat Supply**	0	0	0	-133	0	-15,337	-3,682	0	0	-3,627	22,614	-164	-164	0
280000	**Other Energy Transformation**	0	0	0	63,542	0	0	0	0	0	0	0	63,542	0	63,542
290000	**Total Energy Transformation**	-4,580,043	1,329,492	-7,424,019	6,004,544	-4,898,165	1,176,169	-835,995	-690,638	0	3,718,047	751,794	-5,448,814	-5,442,502	-6,311
300000	**Own Use and Loss**	-23,240	-232,392	-80	-302,403	-134,996	-50,377	0	0	0	-341,039	-4,927	-1,089,454	-1,089,454	0
350000	**Transformation and Consumption Stockpile Change** (+: withdrawal/-: build-up)	57,420	-4,603	-4,703	9,844	-11,937	0	-387	0	0	0	0	45,634	0	45,634
400000	**Statistical Discrepancy** (+: excess/-: shortage)	57,315	-0	-32,634	-43,028	-45,446	13,930	1,068	0	0	-211,099	-43,873	-303,767	-348,033	44,266
500000	**Final Energy Consumption**	431,139	1,174,810	0	6,543,265	63,809	1,125,792	45,123	0	0	3,427,610	746,867	13,558,414	11,959,164	1,599,249
600000	**Industry**	431,100	1,174,810	0	2,968,845	63,809	704,713	30,245	0	0	2,377,257	745,744	8,496,521	6,931,434	1,565,087
610000	**Agriculture, Fishery, Mining and Construction**	0	0	0	215,808	4,713	2,562	0	0	0	41,502	616	265,201	191,152	74,049
620000	**Manufacturing**	431,100	1,158,483	0	2,017,945	59,096	333,442	29,177	0	0	1,110,418	673,567	5,813,228	4,366,455	1,446,772
621000	Manufacture of Food, Beverages, Tobacco and Feed	0	223	0	46,143	0	62,787	0	0	0	89,116	26,281	224,551	224,551	0
622000	Manufacture of Textile Mill Products	0	0	0	23,156	0	20,279	0	0	0	33,894	42,985	120,314	120,314	0
623000	Manufacture of Lumber, Wood Products, Furniture and Fixtures	0	0	0	5,231	0	1,560	0	0	0	12,613	1,317	20,721	20,721	0
624000	Manufacture of Pulp, Paper and Paper Products	0	0	0	19,157	563	8,605	1,155	0	0	109,602	194,720	333,802	333,802	0
625000	Printing and Allied Industries	0	0	0	904	0	6,461	0	0	0	16,463	255	24,082	24,082	0
626000	Manufacture of Chemical and Allied Products, Oil and Coal Products	20	76,988	0	1,708,130	28,841	26,173	2,012	0	0	167,982	263,988	2,274,135	833,386	1,440,748
627000	Manufacture of Plastic Products, Rubber Products and Leather Products	0	0	0	11,278	0	16,201	0	0	0	55,856	5,034	88,370	88,370	0
628000	Manufacture of Ceramic, Stone and Clay Products	149,972	16,454	0	93,960	3,797	35,667	18,432	0	0	83,427	16,103	417,812	413,662	4,150
629000	Manufacture of Iron and Steel	300,305	1,058,401	0	95,252	22,454	105,745	2,565	0	0	321,496	116,091	2,022,309	2,022,207	103
630000	Manufacture of Machinery	0	6,417	0	26,488	2,934	51,226	0	0	0	244,034	36,914	368,013	368,013	0
641000	Miscellaneous Manufacturing Industry	0	0	0	2,274	0	708	0	0	0	7,517	49	10,549	10,549	0
649000	Duplication Adjustment for Manufacturing	-19,198	0	0	-14,029	507	-1,971	5,013	0	0	-31,582	-30,170	-91,430	-93,201	1,771
650000	**Commercial Industry**	0	16,327	0	735,092	0	368,709	1,068	0	0	1,225,337	71,560	2,418,092	2,373,826	44,266
651000	Electricity, Gas, Heat Supply and Water	0	0	0	2,880	0	1,457	0	0	0	72,027	758	77,122	77,122	0
652000	Information and Communications	0	0	0	2,090	0	4,878	0	0	0	97,171	631	104,770	104,770	0
653000	Transport and Postal Activities	0	0	0	75,551	0	2,741	0	0	0	64,365	367	143,024	143,024	0
654000	Wholesale and Retail Trade	0	0	0	86,829	0	26,445	0	0	0	324,630	276	438,180	438,180	0
655000	Finance and Insurance	0	0	0	2,195	0	2,173	0	0	0	16,630	254	21,252	21,252	0
656000	Real Estate and Goods Rental and Leasing	0	0	0	22,986	0	4,307	0	0	0	35,044	101,227	163,564	163,564	0
657000	Scientific Research, Professional and Technical Services	0	0	0	6,555	0	9,614	0	0	0	33,704	544	50,418	50,418	0
658000	Accommodations, Eating and Drinking Services	0	0	0	150,609	0	90,988	0	0	0	161,059	1,586	404,242	404,242	0
659000	Living Related and Personal Services and Amusement Services	0	0	0	120,496	0	70,444	0	0	0	126,924	2,044	319,909	319,909	0
660000	Education, Learning Support	0	0	0	30,770	0	32,493	0	0	0	71,648	317	135,227	135,227	0
661000	Medical, Health Care and Welfare	0	0	0	94,385	0	84,329	0	0	0	145,225	2,970	326,908	326,908	0
662000	Compound Services	0	0	0	1,593	0	100	0	0	0	3,011	0	4,704	4,704	0
663000	Miscellaneous Services	0	16,327	0	61,123	0	17,964	0	0	0	215,747	4,121	315,282	315,282	0
680000	Government	0	0	0	22,072	0	6,846	0	0	0	18,649	338	47,905	47,905	0
690000	Unable to Classify	0	0	0	54,957	0	13,930	1,068	0	0	-160,496	-43,873	-134,414	-178,680	44,266
700000	**Residential**	0	0	0	517,245	0	417,218	14,878	0	0	986,178	1,123	1,936,642	1,936,642	0
800000	**Transportation**	39	0	0	3,057,175	0	3,861	0	0	0	64,175	0	3,125,250	3,091,088	34,162
810000	Passenger Transportation	39	0	0	1,819,705	0	520	0	0	0	61,086	0	1,881,351	1,855,599	25,752
811000	Passenger Vehicle	0	0	0	1,725,409	0	42	0	0	0	0	0	1,725,451	1,699,798	25,652
811500	Bus	0	0	0	58,434	0	478	0	0	0	0	0	58,912	58,912	0
812000	Railway Passenger Transport	39	0	0	6,618	0	0	0	0	0	61,086	0	67,744	67,644	100
813000	Water Passenger Transport	0	0	0	48,868	0	0	0	0	0	0	0	48,868	48,868	0
814000	Air Passenger Transport	0	0	0	125,869	0	0	0	0	0	0	0	125,869	125,869	0
850000	Freight	0	0	0	1,237,469	0	3,341	0	0	0	3,089	0	1,243,899	1,235,489	8,410
851000	Truck and Lorry	0	0	0	1,140,080	0	3,341	0	0	0	0	0	1,143,421	1,140,810	2,610
852000	Railway Freight Transport	0	0	0	1,339	0	0	0	0	0	3,089	0	4,428	4,350	78
853000	Water Freight Transport	0	0	0	104,201	0	0	0	0	0	0	0	104,201	98,479	5,722
854000	Air Freight Transport	0	0	0	23,379	0	0	0	0	0	0	0	23,379	23,379	0
900000	**Final Energy Consumption**	431,139	1,158,314	0	4,977,553	46,767	1,125,792	45,123	0	0	3,427,610	746,867	11,959,164	11,959,164	0
950000	**Non-energy and Feedstock Use**	0	16,496	0	1,565,712	17,041	0	0	0	0	0	0	1,599,249	0	1,599,249
951000	Industry	0	16,496	0	1,531,550	17,041	0	0	0	0	0	0	1,565,087	0	1,565,087
952000	Household	0	0	0	0	0	0	0	0	0	0	0	0	0	0
953000	Transportation	0	0	0	34,162	0	0	0	0	0	0	0	34,162	0	34,162

A4.2.2. General Energy Statistics and CRF

In order to report CO_2 emissions in CRF, emissions reported under the sectors in *General Energy Statistics* (Energy Balance Table) were reported under each sector in CRF. The correspondence of categories between *General Energy Statistics* and CRF table 1.A(a) 'sectoral approach' is indicated in Table A 4-8.

Values subtracting energy consumption reported under 'non-energy and feedstock use' [#950000] from energy consumption reported under 'energy transformation & own use' [#200000], 'industry' [#600000], 'residential' [#700000], and 'transportation' [#800000] in *General Energy Statistics* (Energy Balance Table) are used for activity data. Because energy consumption reported under 'non-energy and feedstock use' [#950000] was used for the purposes other than combustion and was considered not emitting CO_2, these values were deducted. However, out of this amount deducted as feedstock and non-energy use, the emissions from what is used or collected as energy during waste incineration are separately estimated and reported.

The *2006 IPCC Guidelines* requires carbon dioxide emitted from auto power generation, etc., to be counted in the corresponding sector. In Japan's Energy Balance Table (*General Energy Statistics*), fuel consumption used for auto power generation and auto steam generation are presented under 'auto power generation' [#250000], 'auto steam generation' [#260000] in the energy transformation sector. However, auto power generation and auto steam generation actually belong to industry sector. Hence, carbon dioxide emissions from "auto power generation" and "auto steam generation" are allocated to each section of '1.A.2 Manufacturing industries and construction' and '1.A.4 Other sectors'.

In 'energy transformation & own use', 'manufacture of coal products' [#210000], 'oil products' [#220000], 'gas conversion and production' [#230000], 'power generation' [#240000], 'auto power generation' [#250000] , 'auto steam generation' [#260000] , 'district heat supply' [#270000] , and 'own use & loss' [#300000] are calculated, and other sectors ('other energy transformation' and 'transformation and consumption stockpile change') are excluded from calculations.

The energy consumptions recorded under 'manufacture of coal products' correspond to the difference between the coke-making carbon input and carbon output. This is considered to be energy consumption of the portion that is oxidized in the atmosphere (burned) from the time that red-hot coke is extruded from a coke oven until it enters the coke dry quenching facility. It was considered appropriate to count this as CO_2 emissions, and it was calculated as carbon emissions from this sector.

Energy consumptions recorded under 'oil products' correspond to the difference between the carbon input and carbon output for oil products. This is considered to be energy consumption of the portion that is burned carbon precipitated on catalysts in fluid catalytic cracking of oil refining processes for the purpose of recovery of the catalytic activities lowered by the cracking reaction of slack fuel oil, as well as heat recovery at boilers of the off-gas generated in the fluid catalytic cracking mainly consisting of CO, and CO_2 as by-product of hydrogen generating facilities. It was considered appropriate to count this as CO_2 emissions, and it was calculated as carbon emissions from this sector.

Table A 4-8 Correspondence between sectors of General Energy Statistics (Detailed Sector) and of the CRF table 1.A(a)

CRF			General Energy Statistics	
1A1		Energy industries		
	1A1a	Public electricity and heat production	Power generation	#240000
			Own use; Power generation	#301400
			District heat supply	#270000
			Own use; District heat supply	#301500
	1A1b	Petroleum refining	Oil products	#220000
			Own use; Oil products	#301200
			Auto power generation; Manufacture of petroleum products	#253171
			Auto steam generation, Manufacture of petroleum products	#263171
			Final energy consumption, Manufacture of petroleum products	#626510
			Non-energy and feedstock use; Manufacture of petroleum products	#951540
	1A1c	Manufacture of solid fuels and other energy industries	Manufacture of coal products	#210000
			Own use; Coal products	#301100
			Auto power generation; Manufacture of coal products and miscellaneous	#253175
			Auto steam generation, Manufacture of coal products and miscellaneous	#263175
			Final energy consumption; Manufacture of coal products and miscellaneous	#626550
			Gas conversion and production	#230000
			Own use; Gas conversion and production	#301300
1A2		Manufacturing industries and construction		
	1A2a	Iron and steel	Auto power generation; Manufacture of iron and steel	#253250
			Auto steam generation; Manufacture of iron and steel	#263220
			Final energy consumption; Manufacture of iron and steel	#629100
			Non-energy and feedstock use; Manufacture of iron, steel and steel products	#951560
	1A2b	Non-ferrous metals	Auto power generation; Manufacture of non-ferrous metals and products	#253230
			Auto steam generation; Manufacture of non-ferrous metals and products	#263260
			Final energy consumption; Manufacture of non-ferrous metals and products	#629300
			Non-energy and feedstock use; Primary smelting and refining of copper, lead, zinc and aluminium	#951570
	1A2c	Chemicals	Auto power generation; Manufacture of chemical and allied products	#253160
			Auto steam generation; Manufacture of chemical and allied products	#263160
			Final energy consumption; Manufacture of chemical and allied products	#626100
			Non-energy and feedstock use; Manufacture of petrochemical, ammonia, soda products	#951530
	1A2d	Pulp, paper and print	Auto power generation; Manufacture of pulp, paper and paper products	#253140
			Auto power generation; Printing and allied industries	#253150
			Auto steam generation; Manufacture of pulp, paper and paper products	#263140
			Auto steam generation; Printing and allied industries	#263150
			Final energy consumption; Manufacture of pulp, paper and paper products	#624000
			Final energy consumption; Printing and allied industries	#625000
			Non-energy and feedstock use; Manufacture of pulp, paper and paper products, large scale	#951520
	1A2e	Food processing, beverages and tobacco	Auto power generation; Manufacture of food	#253090
			Auto power generation; Manufacture of beverages, tobacco and feed	#253100
			Auto steam generation; Manufacture of food	#263090
			Auto steam generation; Manufacture of beverages, tobacco and feed	#263100
			Final energy consumption; Manufacture of food, beverages, tobacco and feed	#621000
	1A2f	Non-metallic minerals	IE (1A2g)	-

- #9xxxxx items are subtracted as a Non-energy use activity.

Table A 4-8 Correspondence between sectors of General Energy Statistics (Detailed Sector) and of the CRF table 1.A(a) (cont.)

CRF			General Energy Statistics	
	1A2g Other		Auto power generation; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#251010-#251040])	#251000
			Auto power generation; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#252000
			Auto steam generation; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#261010-#261040])	#261000
			Auto steam generation; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#262000
			Final energy consumption; Agriculture, fishery, mining and construction (except for Agriculture, forestry and fishery [#611000])	#610000
			Final energy consumption; Manufacturing (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#620000
			Non-energy and feedstock use; Agriculture, fishery, mining and construction (except for agriculture, forestry and fishery)	#951100
			Non-energy and feedstock use; Manufacturing industry, large scale (except for the industries listed in 1A1b, 1A1c, 1A2a through 1A2e)	#951500
			Non-energy and feedstock use; Manufacturing industry, small and medium scale	#951700
1A3	Transport			
	1A3a Domestic aviation		Final energy consumption; Passenger; Air passenger transport	#814000
			Final energy consumption; Freight; Air freight transport	#854000
			Non-energy and feedstock use; Transportation (air)	#953000
	1A3b Road transportation			
		i Cars	Final energy consumption; Passenger; Passenger vehicle	#811000
			Final energy consumption; Passenger; Estimation discrepancy	#819000
			Non-energy and feedstock use; Transportation (passenger vehicle)	#953000
		ii Light duty trucks	IE (1A3biii)	-
		iii Heavy duty trucks and buses	Final energy consumption; Passenger; Bus	#811500
			Final energy consumption, Freight; Freight truck and lorry	#851000
			Final energy consumption; Freight; Estimation discrepancy	#859000
			Non-energy and feedstock use; Transportation (bus, freight truck and lorry)	#953000
		iv Motorcycles	IE (1A3bi, 1A3biii, 1A4a)	-
		v Other	IE (1A3biii)	-
	1A3c Railways		Final energy consumption; Passenger; Railway passenger transport	#812000
			Final energy consumption; Freight; Railway freight transport	#852000
			Non-energy and feedstock use; Transportation (railways)	#953000
	1A3d Domestic navigation		Final energy consumption; Passenger; Water passenger transport	#813000
			Final energy consumption; Freight; Water freight transport	#853000
			Non-energy and feedstock use; Transportation (water)	#953000
	1A3e Other transportation		NO	-
1A4	Other sectors			
	1A4a Commercial/institutional		Auto power generation (except for Agriculture, fishery, mining and construction [#251000] and Manufacturing [#252000])	#255000
			Auto steam generation (except for Agriculture, fishery, mining and construction [#261000] and Manufacturing [#262000])	#265000
			Final energy consumption; Commercial industry	#650000
			Non-energy and feedstock use; Commercial	#951800
	1A4b Residential		Final energy consumption; Residential	#700000
			Non-energy and feedstock use; Household	#952000
	1A4c Agriculture/forestry/fishing			
		i Stationary	Auto power generation; Agriculture, fishery, mining and construction	#251000
			Auto steam generation; Agriculture, fishery, mining and construction	#261000
			Final energy consumption; Agriculture, Forestry and Fishery (except for off-road vehicles and Fishery [#611300])	#611000
			Non-energy and feedstock use; Agriculture, fishery, mining and construction (agriculture, forestry and fishery)	#951100
		ii Off-road vehicles and other machinery	Final energy consumption; Agriculture (off-road vehicles)	#611100
		iii Fishing	Final energy consumption; Fishery, except aquaculture	#611300

The correspondence of fuels among *General Energy Statistics*, CRF table 1.A(b) 'reference approach' and CRF table 1.A(d) 'non-energy use of fuels' is indicated in Table A 4-9.

Table A 4-9 Correspondence of fuels among *General Energy Statistics*, CRF table 1.A(b) and (d)

Fuel in CRF table 1.A(b) and (d)			Fuel in General Energy Statistics	Code
Liquid fossil	Primary fuels	Crude oil	Crude oil for refinery use	$210
			Crude oil for power generation use	$220
		Orimulsion	Bituminous mixture fuel	$221
		Natural gas liquids	Natural gas liquid (NGL) & condensate	$230
	Secondary fuels	Gasoline	Gasoline	$310
		Jet kerosene	Jet fuel oil	$320
		Other kerosene	Kerosene	$330
		Gas/diesel oil	Gas oil or diesel oil	$340
		Residual fuel oil	Fuel oil A	$351
			Fuel oil B	$356
			Fuel oil C for general use	$357
			Fuel oil C for power generation use	$358
		Liquefied petroleum gas	Liquefied petroleum gas (LPG)	$390
		Naphtha	Pure naphtha	$281
			Reformed feedstock Oil	$282
		Bitumen	Other heavy oil products	$370
		Lubricants	Lubricant oil	$365
		Petroleum coke	Oil coke	$375
		Refinery feedstocks	Slack gasoline	$271
			Slack kerosene	$272
			Slack diesel oil or gas oil	$273
			Slack fuel oil	$274
			Cracked gasoline	$275
			Cracked diesel oil or gas oil	$276
			Feedstock oil for refinery and mixing	$277
		Other oil	Refinery gas	$380
Solid fossil	Primary fuels	Anthracite	Hard coal, anthracite & lignite	$140
		Coking coal	Steel making coal	$110
		Other bituminous coal	Imported steam coal for general use	$131
			Imported steam coal for power generation use	$132
		Sub-bituminous coal	Indigenous produced steam coal	$135
	Secondary fuels	BKB and patent fuel	Coal briquette	$163
		Coke oven/gas coke	Coke	$161
			Coke oven gas	$171
			Blast furnace gas	$172
			Converter furnace gas	$175
		Coal tar	Coal tar	$162
Gaseous fossil		Natural gas	Liquefied natural gas (LNG)	$410
			Indigenous natural gas	$421
			Coal mining gas	$422
			Boil off gas from crude oil	$423
			Town gas	$460
			Small scale community gas	$470
Biomass		Solid biomass	Biomass power generation	$N131
			Solid biomass	$N133
			Thermal use of black liquor	$N136
			Thermal use of waste woods	$N137
		Liquid biomass	Liquid biomass	$N134
		Gas biomass	Gas biomass	$N135

A4.2.3. Duplication adjustment for Energy Balance Table

The data set of the manufacturing sector indicated in Japan's Energy Balance Table (*General Energy Statistics*) and used as the reference of activity data are based on the Ministry of Economy, Trade and Industry's *Yearbook of the Current Survey of Energy Consumption* and the Agency for Natural Resources and Energy's *Statistical Survey of Energy Consumption. The Yearbook of the Current Survey of Energy Consumption* is a statistical survey on large scale factories and business institutions of key manufacturing. Factories and business institutions which produce items indicated in Table A 4-10 are surveyed.

In Japan, it is rare that single factory or business institution produces single item. Most factories and business institutions produce various items extending across categories of industry utilizing by-products and surplus business resources. For example, most integrated steelworks produce not only steel products falling into iron & steel industry but also coke and slag cement falling into cement & ceramics industry and chemical products delivered from coal tar and industrial gas falling into chemical industry; i.e. one factory can conduct three different categories of industries and produces many kinds of items at the same time.

Because single factory may report duplicated energy consumption data which cannot be classified to certain sector or item, total energy consumption summed up by sector or by item can be larger than actual total energy consumption when totalizing by sector or by item is conducted under the *Yearbook of the Current Survey of Energy Consumption.*

Hence, to avoid duplication adjustment and to adjust the data in the *Yearbook of the Current Survey of Energy Consumption,* the following steps were taken: (1) to calculate total energy consumption by factory and business institution, (2) to calculate total energy consumption by sector and by item including duplication among sectors and items, (3) to express the difference between total energy consumption by sector and by item and total energy consumption by factory and by business as negative values as "duplication adjustment".

In the *Yearbook of the Current Survey of Energy Consumption,* the adjustment stated above is applied indicating values for "duplication adjustment" when total energy consumption is calculated by sector or by item for 'auto power generation; manufacturing' [#252000], 'auto steam generation; manufacturing' [#262000], and 'final energy consumption; manufacturing' [#620000].

Calculation method for duplication adjustment

Values of duplication adjustment $= E_p - E_t$

E_p :Total energy consumption of designated sectors and items by factories and business institutions
E_t : Total energy consumption by factories and business institutions

Subjects to be surveyed to obtain the data for the *Yearbook of the Current Survey of Energy Consumption* were changed in December, 1997. As shown in Table A 4-10, the survey for the industries of dyeing, rubber product, and non-ferrous metals has been discontinued since 1998. Also, since 1998, business institutions or designated items to be surveyed for the industries of chemical, ceramics, clay and stone products, glass products, iron and steel, non-ferrous metals, and machinery has been changed. Therefore, energy consumption for large scale factories and business institutions of the said industries during 1990-1997 is chronologically inconsistent comparing to that from 1998 and

onward. Also, the classification of industries was revised during this period. Because of these changes, energy consumption for duplication adjustment significantly fluctuates.

Table A 4-10 Surveyed industries and products in *Yearbook of the Current Survey of Energy Consumption*

Surveyed industry	From 1990 to 1997		After 1997	
	Products	Scope of survey	Products	Scope of survey
Pulp and paper industry	· Pulp · Paper · Sheet paper	All Establishments with 50 or more employees Establishments with 50 or more employees	· Pulp · Paper · Sheet paper	All Establishments with 50 or more employees Establishments with 50 or more employees
Chemical industry (except chemical fiber industry)	· Petrochemical products · Ammonia and ammonia-derived products · Soda industries chemicals · High pressure gas (O_2, N_2, Ar) · Inorganic chemicals and colorant (titanic oxide, active char, chinese white, iron oxide) · Oil and fat products and surfactant	All All All All (except high pressure gas products by air fraction method (gas container)) All Establishments with 30 or more employees	· Petrochemical products · Ammonia and ammonia-derived products · Soda industries chemicals	All
Chemical fiber industry	Chemical fibers	Establishments with 30 or more employees	Chemical fibers	Establishments with 30 or more employees
Petroleum products industry	Petroleum products (except grease)	All	Petroleum products (except grease)	All
Ceramics, clay and stone products industry (except glass product industry, with the exception of sheet glass industry)	· Cement · Sheet glass · Lime · Fire brick · Carbon products	All All Establishments with 30 or more employees Establishments with 30 or more employees All	· Cement · Sheet glass · Lime	All All Establishments with 30 or more employees
Glass product industry (except sheet glass industry)	Glass products	Establishments with 10 or more employees	Glass products	Establishments with 100 or more employees
Iron and steel industry	Manufacturers of pig iron, ferroalloys, crude steel, semi-finished steel products, forged steel products, cast steel products, general steel and hot-rolled steel materials, cold-rolled wide steel strips, cold-rolled electrical steel strips, plated steel materials, special steel hot-rolled steel materials, steel pipes (except coldworking steel pipes), or cast iron tubes	All	Manufacturers of pig iron, ferroalloys, crude steel, semi-finished steel products, forged steel products, cast steel products, general steel and hot-rolled steel materials, cold-rolled wide steel strips, cold-rolled electrical steel strips, plated steel materials, special steel hot-rolled steel materials, steel pipes (except coldworking steel pipes), or cast iron tubes	All
Non-ferrous metal industry	Non-ferrous metals	All	· Copper · Lead · Zinc · Aluminum · Alminum secondary ground matal	All All All All Establishments with 30 or more employees
Machinery industry	· Machinery and appliances · Cast and forged products	Establishments with 500 or more employees Establishments with 100 or more employees	· Civil engineering machinery, tractors, metal working and metal processing machinery · Parts and accessories for communication and electronics equipment · Electron tubes, semiconductors, integrated circuits · Electronics applied equipment · Automobiles and parts (including motorcycles)	Establishments with 500 or more employees which are designated by the Minister of International Trade and Industry
Dyeing	· Dyeing wool · Dyeing fablic	Establishments with 20 or more employees	Demise	
Rubber product	Tires and tube	Establishments with 30 or more employees	Demise	
Non-ferrous metal product	· Copper and brass · Flat-rolled aluminum · Electric cable · Alminum secondary bare metal	All All Establishments with 30 or more employees Establishments with 30 or more employees	Demise	

A4.3. Quality Standard for Diesel Oil

The carbon emission factor for liquid fuels (diesel oil) in 1.A.3.b (Road transportation) is the lowest in Annex I Parties for two reasons. One is because the quality standard for diesel oil in Japan is different from other countries. Crude oil with high sulfur content imported from the Middle East must be decomposed and go through ultra-deep desulfurization to become low-sulfur diesel oil (<10 ppm) according to Japanese automobile exhaust gas regulations. The other reason is because gas oil used for purposes other than road transport is called "fuel oil A" to distinguish it from diesel oil. The carbon balance of Japanese petroleum refineries including diesel oil and fuel oil A nearly matches according to statistics, so these carbon emission factors are not irregular.

In the individual review on Japanese greenhouse gas inventory conducted in September 2012, the ERT (Expert Review Team) asked Japan for the possibility of involving the information on Japanese quality standard of diesel oil in the future NIR. In correspondence to the question, Japan has provided the information on Japanese quality requirement of diesel oil mainly used for automobile engine in the Table A 4-11 below. In this standard, the diesel oil is classified into five types based on the pour point difference. Also, the standard meets with the Japanese law “Act on the Quality Control of Gasoline and Other Fuel” as a matter of course.

Table A 4-11 Required quality of diesel oil in Japan

Test item	Unit	Type				
		S1	1	2	3	S3
Flash point	°C	50 or more			45 or more	
90 % distilling temperature	°C	360 or less		350 or less	330 or less [a)]	330 or less
Pour point	°C	5 or less	-2.5 or less	-7.5 or less	-20 or less	-30 or less
Cold filter plugging point	°C	–	-1 or less	-5 or less	-12 or less	-19 or less
Residual carbon ratio in 10 % residual oil	% in weight	0.1 or less				
Cetane index [b)]	–	50 or more		45 or more		
Kinetic viscosity at 30 °C	mm^2/s	2.7 or more		2.5 or more	2.0 or more	1.7 or more
Sulfur ratio	% in weight	0.0010 or less				
Density at 15 °C	g/cm^3	0.86 or less				

a) 350 or less, if the kinetic viscosity at 30 °C is 4.7 m^3/s or less.
b) Cetane number is also available for cetane index.
Source: Japanese Industrial Standards K 2204, revised in 2007

References

1. Environmental Agency, *The Report on Estimation of CO_2 Emissions in Japan*, 1992.
2. Research Institute of Economy, Trade & Industry, Kazunari Kainou, *Interpretation of General Energy Statistics*, 2012.
3. Japanese Industrial Standards K 2204, revised in 2007.
4. OECD/IEA, *Energy Statistics of OECD Countries*
5. Agency for Natural Resources and Energy, *General Energy Statistics*

Annex 5. Assessment of Completeness, Definition of Notation Keys, and Sources and Sinks Reported as "NE"

A5.1. Assessment of Completeness

Current inventory is submitted in accordance with the common reporting format (CRF), which requires entering emission data or a notation key such as "NO", "NE", or "NA" for all sources. This chapter presents the definition of notation keys and decision trees for the application of them (including applicability criteria of "NE" when the emissions are considered insignificant), both of which are based on the UNFCCC reporting guidelines (Decision 24/CP.19) and the results of Committee for Greenhouse Gases Emissions Estimation Methods in 2002, 2012, and 2014.

This chapter also indicates classification of emission source categories reported as "NE" into one which are considered insignificant and the other which are not estimated.

A5.2. Definition of Notation Keys

In Japan, notation keys are used in accordance with UNFCCC reporting guidelines (Decision 24/CP.19). The following table A5-1 indicates definitions of notation keys provided in the UNFCCC reporting guidelines.

Table A 5-1 Definitions of notation keys indicated in UNFCCC reporting guidelines

Notation Key	Explanation
NO (Not Occurring)	(a) "NO" (not occurring) for categories or processes, including recovery, under a particular source or sink category that do not occur within an Annex I Party;
NE (Not Estimated)	(b) "NE" (not estimated) for emissions by sources and removals by sinks of GHGs and AD which have not been estimated but for which a corresponding activity may occur. When "NE" is used, the reason should be indicated in both the NIR and the CRF. Also, when emissions from a specific category are considered to be insignificant, "NE" can be used. In such case, justifications for exclusion in terms of the likely level of emissions should be provided in NIR. An emission should only be considered insignificant if the likely level of emissions is below 0.05 per cent of the national total GHG emissions and does not exceed 500kt CO_2 eq. The total national aggregate of estimated emissions for all gases and categories considered insignificant shall remain below 0.1 per cent of the national total GHG emissions. Parties should use approximated AD and default IPCC EFs to derive a likely level of emissions for the respective category. Once emissions from a specific category have been reported in a previous submission, emissions from this specific category shall be reported in subsequent GHG inventory submissions;
NA (Not Applicable)	"NA" (not applicable) for activities under a given source/sink category that do occur within the Party but do not result in emissions or removals of a specific gas. If the cells for categories in the CRF tables for which "NA" is applicable are shaded, they do not need to be filled in;
IE (Included Elsewhere)	"IE" (included elsewhere) for emissions by sources and removals by sinks of GHGs estimated but included elsewhere instead of under the expected source/sink category. Where "IE" is used, the Annex I Party should indicate where the emissions or removals have been included and explain why they have been reported in that category in the CRF completeness table, especially if it is due to confidentiality;
C (Confidential)	"C" (confidential) for emissions by sources and removals by sinks of GHGs of which the reporting could lead to the disclosure of confidential information, in accordance with paragraph 36. (Paragraph 36: Emissions and removals should be reported at the most disaggregated level of each source/sink category, taking into account that a minimum level of aggregation may be required to protect confidential business and military information.)

Source : UNFCCC reporting guidelines on annual greenhouse gas inventories (Decision 24/CP.19)

Applicability criteria for "NE" when the emissions are considered insignificant was stipulated by the Committee for the Greenhouse Gas Emissions Estimation Methods in FY2012 and FY2014, as shown in the following decision tree (Figure A5-2).

If the UNFCCC reporting guidelines are revised in the future, the definition of notation keys and the reporting method will be reviewed.

A5.3. Decision Tree for Application of Notation Keys

Decision tree for the application of notation keys, based on UNFCCC reporting Guidelines (Decision 24/CP.19) and the results of Committee for Greenhouse Gases Emissions Estimation Methods in FY2002, FY2012, and FY2014, is shown in Figure A5-1.

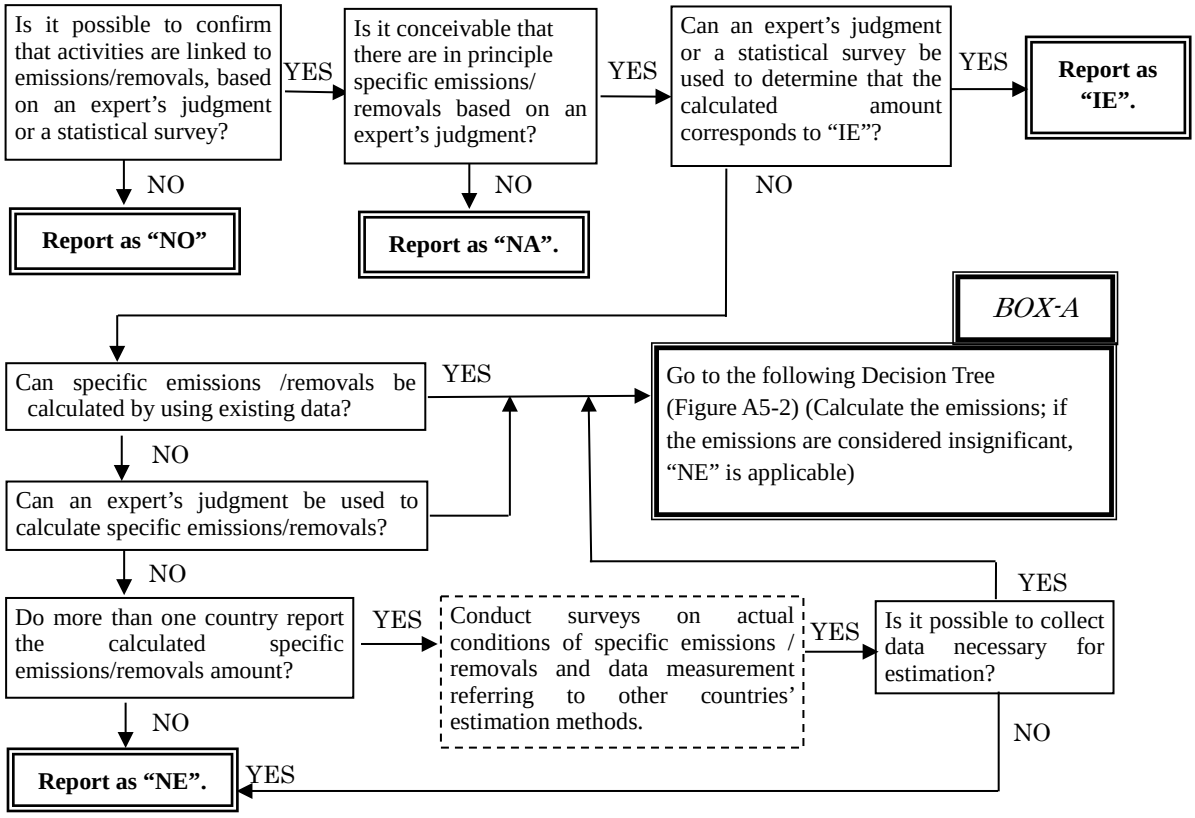

Figure A 5-1 Decision tree for application of notation keys

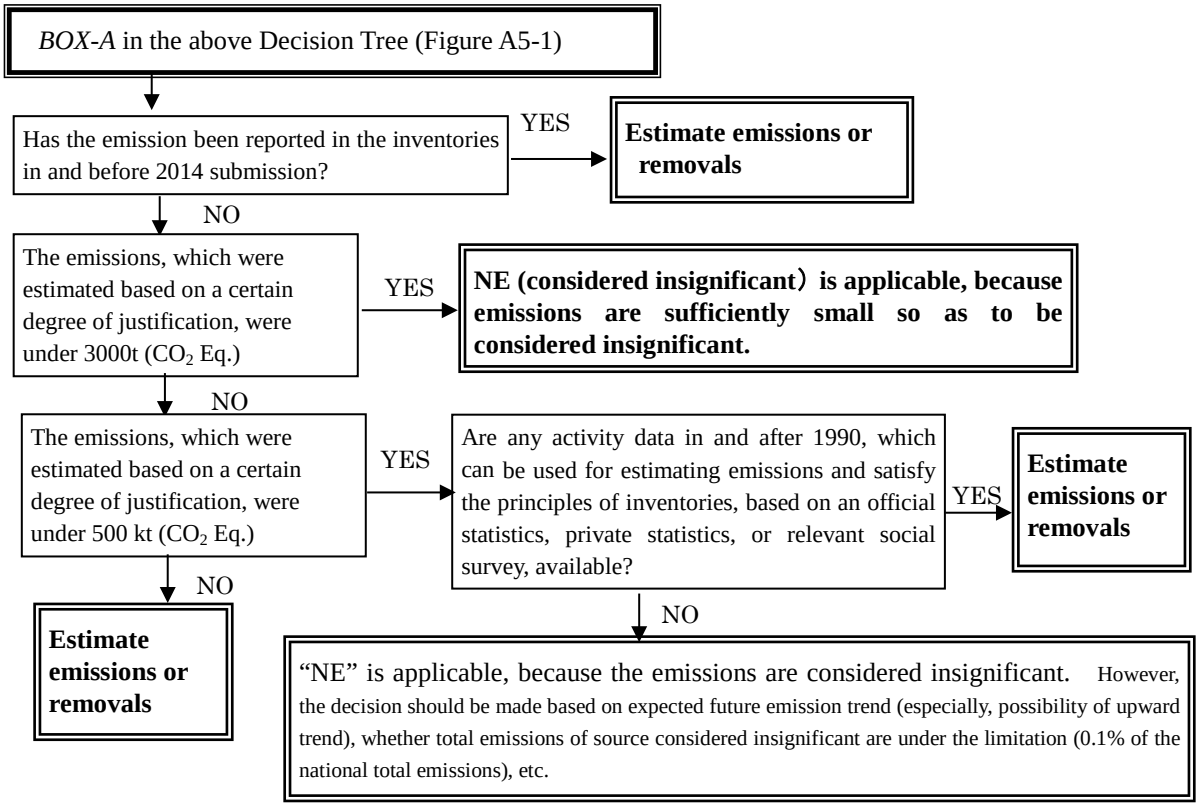

Figure A 5-2 Decision tree for determining applicability of "NE" when the emissions are considered insignificant

When emissions by sources and removals by sinks of GHGs could be confidential information, they are reported as "C".

A5.4. Emission sources reported as "NE" (considered insignificant) in Japan

The notation key NE (considered insignificant) was used for the emission source categories indicated in the following Table A5-2, because the emissions are sufficiently small so as to be considered insignificant. Since the approximate total amount of emissions from these emission sources (excluding removal) is 40 kt (in CO_2 eq.) at maximum, it is not expected to exceed 0.1% of the national total emissions (approximately 1.3Mt. (in CO_2 eq. for Japan), which is stipulated in paragraph 37(b) in the UNFCCC reporting guidelines (Decision 24/CP.19) as the upper limit of applicability of "NE" for being considered insignificant.

Table A 5-2 Emission sources reported as "NE" (considered insignificant)

Code	Category No.	Sector and Category			Gas	Likely Level Emissions [kt-CO_2eq]
1	1.C.	Energy	CO_2 transport and storage		CO_2	< 0.007
2	2.F.4.	IPPU	Product uses as substitutes for ODS	Aerosols	HFCs	<1.8
3	2.G.2.	IPPU	Other product manufacture and use	Soundproof windows	SF6	<0.3
4	3.A.4.-	Agriculture	Enteric Fermentation	Deer	CH_4	< 2.3
5	3.A.4.-	Agriculture	Enteric Fermentation	Alpaca	CH_4	< 0.07
6	3.B.4.-	Agriculture	Manure Management	Deer	CH_4	<0.03
7	3.B.4.-	Agriculture	Manure Management	Reindeer	CH_4	<0.01
8	3.B.4.-	Agriculture	Manure Management	Silver Fox	CH_4	<0.04
9	3.B.4.-	Agriculture	Manure Management	Other Poultry (Duck, Turkey, Quail, Goose, Guinea Fowl, Pheasant)	CH_4	<0.8
10	3.B.4.-	Agriculture	Manure Management	Deer	N_2O	<0.6
11	3.B.4.-	Agriculture	Manure Management	Reindeer	N_2O	<0.02
12	3.B.4.-	Agriculture	Manure Management	Silver Fox	N_2O	<0.01
13	3.B.4.-	Agriculture	Manure Management	Other Poultry (Duck, Turkey, Quail, Goose, Guinea Fowl, Pheasant)	N_2O	<0.3
14	4.D.1.	LULUCF	Wetlands Remaining Wetlands	Peat Production	CO_2	<30
15	4.D.	LULUCF	Wetlands	Biomass Burning	CO2,CH4,N2O	<1.2
Total						**<40**

* Maximum possible amount of emissions between FY 1990 and the latest year, under certain assumptions and based on simple estimation methods such as Tier 1

A5.5. Source and sink categories not estimated in Japan's inventory

The following table A5-3 indicates source and sink categories which were not estimated, excluding "NE" applicable categories for being "considered insignificant" as described above.

Table A 5-3 Source and sink categories which were not estimated in Japan's inventory

Code	Sector	Source and sink category				GHG
1	Energy	Fuel Combustion, Transportaion	Liquid Fuels	Domestic Aviation	Cruise	CH_4
2	Energy	Fuel Combustion	Liquid Fuels	Lubricants		CH_4
3	Energy	Fuel Combustion	Liquid Fuels	Lubricants		N_2O
4	Energy	Fugitive Emissions from Fuels	Solid Fuels	Coal Mining and Handling	Recovery/Flaring	CH_4
5	Energy	Fugitive Emissions from Fuels	Solid Fuels	Others (Uncontrollable Combustion)		CO_2
6	Energy	Fugitive Emissions from Fuels	Oil and Natural Gas	Oil	Refining/Storage	CO_2
7	Energy	Fugitive Emissions from Fuels	Oil and Natural Gas	Oil	Distribution of Oil Products	CO_2
8	Energy	Fugitive Emissions from Fuels	Oil and Natural Gas	Oil	Distribution of Oil Products	CH_4
9	IPPU	Chemical Industry	Ammonia Production			CH_4
10	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	CO_2
11	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	CH_4
12	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	N_2O
13	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	CO_2
14	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	CH_4
15	LULUCF	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	N_2O
16	LULUCF	Wetlands	Wetlands remaining Wetlands	Flooded land	Living Biomass	Carbon Stock Change
17	LULUCF	Wetlands	Wetlands remaining Wetlands	Flooded land	Dead Organic Matter	Carbon Stock Change
18	LULUCF	Wetlands	Wetlands remaining Wetlands	Flooded land	Soil	Carbon Stock Change
19	LULUCF	Wetlands	Land converted to Wetlands	Cropland converted to Wetlands	Soil	Carbon Stock Change
20	LULUCF	Wetlands	Land converted to Wetlands	Grassland converted to Wetlands	Soil	Carbon Stock Change
21	LULUCF	Wetlands	Land converted to Wetlands	Settlements converted to Wetlands	Soil	Carbon Stock Change
22	LULUCF	Wetlands	Land converted to Wetlands	Other Land converted to Wetlands	Soil	Carbon Stock Change
23	LULUCF	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Living Biomass	Carbon Stock Change
24	LULUCF	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Dead Organic Matter	Carbon Stock Change
25	LULUCF	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Soil	Carbon Stock Change
26	LULUCF	Settlements	Settlements remaining Settlements	Urban Green Areas not subject to RV	Dead Organic Matter	Carbon Stock Change
27	LULUCF	Settlements	Settlements remaining Settlements	Urban Green Areas not subject to RV	Soil	Carbon Stock Change

Annex 6. Hierarchical Structure of Japan's National GHG Inventory File System

Multiple MS Excel files have been used when estimating Japanese inventory. The explanation of each MS Excel file and the hierarchical structure of Japanese National GHGs Inventory (JNGI) file system are shown below.

Table A6-1 Explanation of each MS Excel file

category	file name	contents
	JPN_2016_1990.xlsx - JPN_2016_2014.xlsx,	Common reporting format generated by CRF reporter
1. Energy	1A-L3-CO2-1990-2016.xlsx - 1A-L3-CO2-2014-2016.xlsx	CO_2 emissions from fuel combustions
	1A-L3-CRF-2016.xlsx	CRF format data of GHG emissions from fuel combution (including emissions by energy use of waste)
	1A-L3-timeseries-2016.xlsx	Time-series data of GHG emissions from fuel combution
	1A-L2-MAP_EB-1990-2016.xlsx - 1A-L2-MAP_EB-2014-2016.xlsx	Activity Data for furnaces
	1A-L3-CO-2016.xlsx	CO emissions from furnace and off-road vehicle
	1A-L3-HC-2016.xlsx	CH_4, NMVOC emissions from furnace and off-road vehicle
	1A-L3-N2O-2016.xlsx	N_2O emissions from furnace and off-road vehicle
	1A-L3-NOxSO2-2016.xlsx	NOx, SO_2 emissions from furnace and off-road vehicle
	1A-L2-nonCO2-ADEF-2016.xlsx	Activity Data and Emission Factors of Non-CO_2 from fuel combustion
	1A-L2-nonCO2-EF-2016.xlsx	Emission Factors of Non-CO_2 from fuel combustion
	1A-L3-Lub-2016.xlsx	CO_2 emissions from lubricant
	1A-L2-EBEF-2016.xlsx	Emission Factors for CO_2 from fuel combustion
	1A-L1-EB-2016.xlsx	Data of the General Energy Statistics using in Mobile (CH_4, N_2O), Fugitive emissions from fuels and IP sector
	1A3-L3-CH4N2O-2016.xlsx	GHG emissions from Mobile Combustion (transport sector) (except CO_2)
	1A3-L2-ADEF-2016.xlsx	Activity Data and Emission Factors for Mobile Combustion (transport sector)
	1B-L3-2016.xlsx	Fugitive GHG emissions from fuels
	1B-L2-ADEF-2016.xlsx	Activity Data and Emission Factors for Fugitive Emissions from Fuels
2. Industrial Processes and Other Product Use (IPPU)	2-L2-ADEF-2016.xlsx	Activity Data and Emission Factors of Sector 2 (except F-gas)
	2-L3-2016.xlsx	GHG emissions from Sector 2 (IPPU)
	2-L3-Fgas-2016.xlsx	F-gas (HFCs, PFCs, SF_6, NF_3) emissions
	2-L3-NMVOC-2016.xlsx	NMVOC emissions in Industrial Processes
	2-L2-NMVOC-2016.xlsx	AD and EF for NMVOC emissions in Industrial Processes
3. Agriculture	3A-L3-CH4-2016.xlsx	CH_4 emissions from enteric fermentation
	3B-L3-CH4N2O-2016.xlsx	GHG emissions from manure management
	3C-L3-CH4-2016.xlsx	CH_4 emissions from rice cultivation
	3D-L3-N2O-2016.xlsx	N_2O emissions from agricultural soils
	3F-CH4N2OCO-2016.xlsx	GHG emissions from field burning of agricultural residues
	3GH-L3-CO2-2016.xlsx	CO_2 emissions from lime application and urine application to agricultural soil
	3-L2-ADEF-2016.xlsx	Activity Data and Emission Factors of Sector 3
4. LULUCF	4-L3-nonCSC-2016.xlsx	GHG emissions excluindg carbon stock change
	4-L3-4A-CO2-2016.xlsx	CO_2 emissions and removals from forest land
	4-L3-4B-CO2-2016.xlsx	CO_2 emissions and removals from cropland
	4-L3-4C-CO2-2016.xlsx	CO_2 emissions and removals from grassland
	4-L3-4D-CO2-2016.xlsx	CO_2 emissions and removals from wetlands
	4-L3-4E-CO2-2016.xlsx	CO_2 emissions and removals from settlements
	4-L3-4F-CO2-2016.xlsx	CO_2 emissions and removals from other land
	4-L3-4G-CO2-2016.xlsx	CO_2 emissions from HWP
	4-L2-Area(Pref.)-2016.xlsx	Mineral and Organic Soil Area
	4-L2-LandArea-2016.xlsx	Land area for each land use category
	4-L2-LandArea-Matrix-2016.xlsx	Land-use matrix
	4-L2-Orcahrd-2016.xlsx	Carbon stock changes in orchard
	4-L2-Parameter-2016.xlsx	Parameters for each land use category
	4-L2-Soil-2016.xlsx	Land area and carbon stock changes in cropland and grassland
5. Waste	5A3-L2-AD-2016.xlsx	Activity data of solid waste disposal (other)
	5A-L3-2016.xlsx	GHG emissions from solid waste disposal
	5A-L2-AD-2016.xlsx	Activity data of solid waste disposal (managed disposal site)
	5B-L3-2016.xlsx	GHG emissions from biological treatment of solid waste
	5B-L2-AD-2016.xlsx	Activity data of biological treatment of solid waste
	5C-L2-AD-2016.xlsx	Activity data of incineration and open burning of waste
	5C-L3-2016.xlsx	GHG emissions from incineration and open burning of waste
	5C-L3-Energy-2016.xlsx	GHG emissions from waste incineration and energy use (reported on energy sector)
	5D-L3-2016.xlsx	GHG emissions from waste water treatment and discharge
	5D-L2-AD-2016.xlsx	Activity data of waste water treatment and discharge
	5E-L3-2016.xlsx	GHG emissions from other
	5E-L2-AD-2016.xlsx	Activity data of other
	5-L2-EF-2016.xlsx	Emission factors of Sector 5 (Waste)
6. Other	6-L3-2016.xlsx	CO Emissions from tobaccos
Memo Item	1D-L3-bunker-2016.xlsx	GHGs emissions from bunker fuels
KP-LULUCF	4KP-3-Summary-2016.xlsx	GHG emissions and removals from KP3.3 and 3.4 activities
	4KP-2-AR-2016.xlsx	GHG emissions and removals from Afforestation/Reforestation
	4KP-2-CM-2016.xlsx	GHG emissions and removals from Cropland Management
	4KP-2-D-2016.xlsx	GHG emissions and removals from Deforestation
	4KP-2-FM-2016.xlsx	GHG emissions and removals from Forest Management
	4KP-2-GM-2016.xlsx	GHG emissions and removals from Grassland Management
	4KP-2-RV-2016.xlsx	GHG emissions and removals from Revegetation

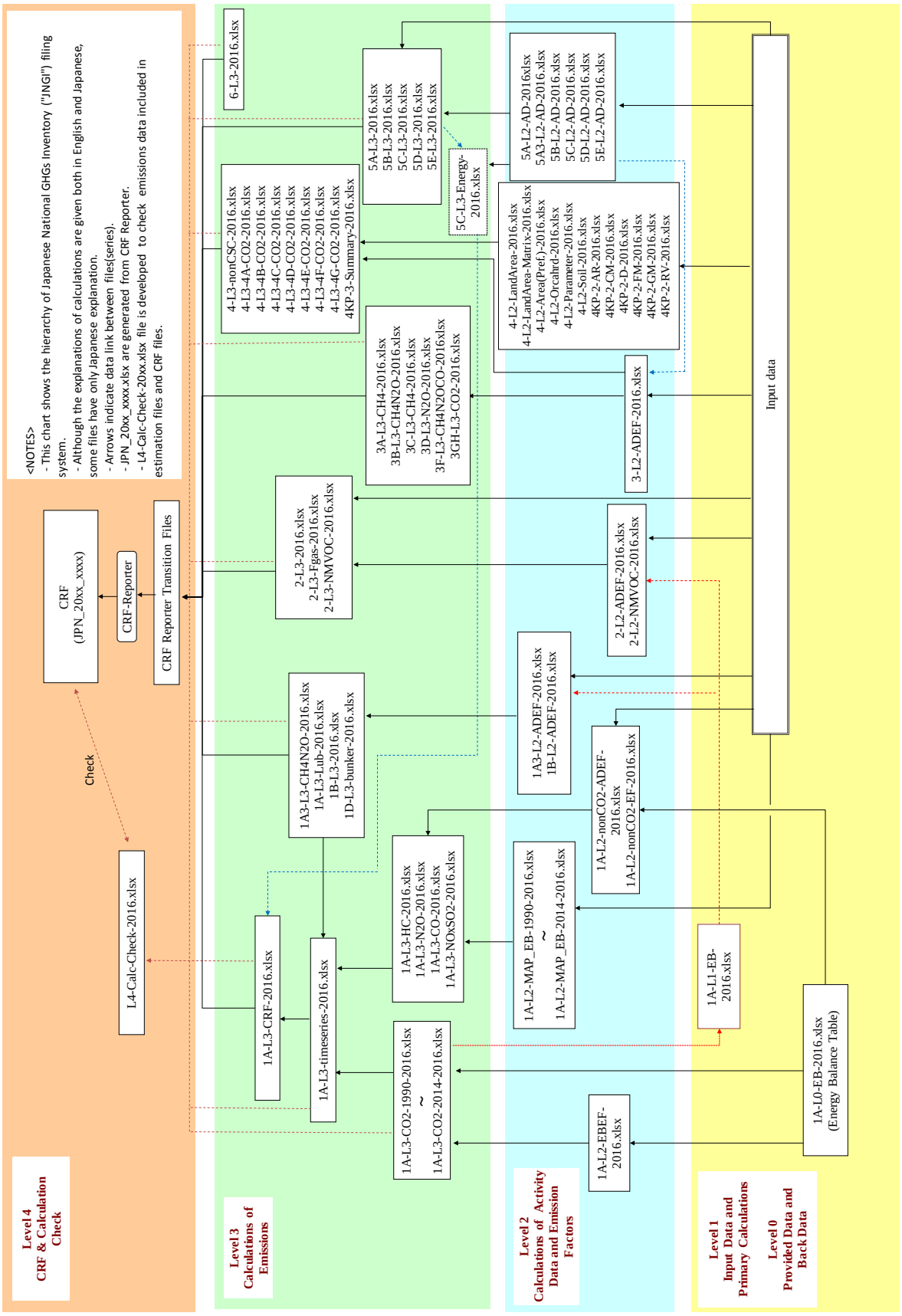

Figure A 6-1 Hierarchical structure of Japan's National GHG Inventory File System

Abbreviations

1. Greenhouse Gases

Table AB-1 Greenhouse Gases

Term	Gas
CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride
NF_3	Nitrogen trifluoride

Table AB-2 Precursors and SO_X

Term	Gas
NOx	Sum of nitrogen oxide and nitrogen dioxide
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds
SO_x	Sulfur oxide

2. Prefixes and Units

Table AB-3 Prefixes

Term	Prefix	Definition
P	peta	10^{15}
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
h	hecto	10^{2}
da	deca	10^{1}
d	deci	10^{-1}
c	centi	10^{-2}
m	milli	10^{-3}
μ	micro	10^{-6}

Table AB-4 Units

Term	Definition
m^3	cubic metre
l	litter
a	are
ha	hectare
g	gram
t	tonne
J	joule
°C	degree Celsius
yr	year
cap	capita
d.m.	dry matter

3. Notation Keys

Table AB-5 Notation keys (See Annex 5 for details)

Notation Key	Definition
NO	Not Occurring
NE	Not Estimated
NA	Not Applicable
IE	Included Elsewhere
C	Confidential

4. Other Abbreviations

Table AB-6 Abbreviations

	Terms	Definition
A	AAU	Assigned Amount Units
	AD	Activity Data
	ARD	Afforestation, Reforestation and Deforestation
B	BFG	Blast Furnace Gas
	BOD	Biochemical Oxygen Demand
C	CFG	Converter Furnace Gas
	CGER	Center for Global Environmental Research
	CM	Cropland Management
	CO_2 eq.	Gas Emission in CO_2 equivalent
	COD	Chemical Oxygen Demand
	COG	Coke Oven Gas
	CRF	Common Reporting Format
	CS-EF	Country-Specific Emission Factor
	CY	Calendar Year
E	EEA	European Environment Agency
	EF	Emission Factor
	EMEP	European Monitoring and Evaluation Programme
F	FM	Forest Management
	FY	Fiscal Year
G	GCV	Gross Calorific Value
	GHG	Greenhouse Gas
	GIO	Greenhouse Gas Inventory Office
	GM	Grazing Land Management
	GPG	Good Practice Guidance
	GPG (2000)	Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)
	GPG-LULUCF	Good Practice Guidance for Land Use, Land-Use Change and Forestry
	GWP	Global Warming Potential
I	IEA	International Energy Agency
	IEF	Implied Emission Factor
	IPCC	Intergovernmental Panel on Climate Change
J	JNGI	Japanese National GHG Inventory
K	KP	Kyoto Protocol
L	LNG	Liquefied Natural Gas
	LPG	Liquefied Petroleum Gas
	LTO	Landing and Take-off
	LULUCF	Land-Use, Land-Use Change and Forestry
M	MAFF	Ministry of Agriculture, Forestry and Fisheries
	MDI	Metered Dose Inhalers
	METI	Ministry of Economy, Trade and Industry
	MOE	Ministry of the Environment
	MOFA	Ministry of Foreign Affairs of Japan
	MIC	Ministry of Internal Affairs and Communications
	MLIT	Ministry of Land, Infrastructure and Transport and Tourism
	MSW	Municipal Solid Waste
N	NCV	Net Calorific Value
	NFRDB	National Forest Resource DataBase
	NGL	Natural Gas Liquids
	NIES	National Institute for Environmental Studies
	NIR	National Inventory Report
Q	QA/QC	Quality Assurance / Quality Control
	QAWG	Quality Assurance Working Group

Table AB-6 Abbreviations (Continue)

	Terms	Definition
R	RDF	Refuse Derived Fuel
	RPF	Refuse Paper and Plastic Fuel
	RV	Revegetation
S	SEF	Standard Electronic Format
T	THC	Total Hydrocarbon
	TOE	Tonnes of Oil Equivalent
U	UNFCCC	United Nations Framework Convention on Climate Change