National Greenhouse Gas Inventory Report of JAPAN

April, 2014

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 (2014)

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Foreword

On the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and Article 7 of the Kyoto Protocol, all Parties to the Convention are required to submit national inventories of greenhouse gas emissions and removals to the secretariat of the Convention. 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 UNFCCC Inventory Reporting Guidelines (FCCC/SBTA/2006/9) and Decision 15/CMP.1.

This Report presents Japan's institutional arrangement for the inventory preparation, the estimation methods of greenhouse gas emissions and removals from sources and sinks, the trends in emissions and removals for greenhouse gases (carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6)) and precursors (nitrogen oxides (NO_X), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), and sulfur dioxide (SO_2)). 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 recommended structure indicated in the Annex I of UNFCCC Inventory Reporting Guidelines (FCCC/SBSTA/2006/9) and the "Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol" prepared by the UNFCCC secretariat.

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, the institutional arrangement for the inventory preparation, inventory preparation process, methodologies and data sources used, key source 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 8 provide the detailed estimation methods for emissions and removals respectively, described in the *Revised 1996 IPCC Guidelines*. Chapter 9 comprises current status of reporting of the emissions from sources not covered by IPCC guidelines. Chapter 10 provides the explanations on improvement and recalculation (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, 2014
Low-carbon Society Promotion Office
Global Environment Bureau
Ministry of the Environment

Preface

The Kyoto Protocol accepted by Japan in June 2002 targets the reduction of six greenhouse gases (GHGs): carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6). Quantified targets for reductions in emissions of greenhouse gases have been 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) is to reduce average emissions of greenhouse gases by six percent from the base year (1990 for carbon dioxide, methane and nitrous oxide, and 1995 for HFCs, PFCs, and sulfur hexafluoride). 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 (2007). The GHGs inventories have been therefore authoritative data for Japan in reporting its achievement of the Kyoto Protocol's commitment.

The GHGs 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 has been often held since then.

In compiling GHGs inventories, the Greenhouse Gas Inventory Office of Japan (GIO) would like to acknowledge not just the work of the Committee members in seeking to develop the methodology, but other experts who provided the latest scientific knowledge, the industrial bodies and government departments and agencies that provided the data necessary for compiling the inventories. 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 final submission of the inventory in the first commitment period to the secretariat of the United Nations Convention on Climate Change (UNFCCC). Getting many feedbacks from 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 measures implemented against global warming of Japan.

My appreciation also extends to Dr. Junko AKAGI who worked with us until 2013 summer, Ms. Yuriko ASANUMA, Ms. Mutsuko FUJII and Ms. Kyoumi ISHIGAMI, our assistants, who supported us with the smooth operation of GIO.

April, 2014

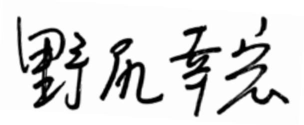

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Table of Contents

Foreword ____ i
Preface ____ iii
Contents ____ v

EXECUTIVE SUMMARY OF NATIONAL GHGS INVENTORY REPORT OF JAPAN 2014 ____ 1
E.S.1. Background Information on GHGs Inventories, Climate Change and Supplementary Information Required under Article 7, Paragraph 1, of the Kyoto Protocol ____ 1
E.S.2. Summary of National Emission and Removal Related Trends, and Emission and Removals from KP-LULUCF Activities ____ 2
2.1. GHG Inventory ____ 2
2.2. KP-LULUCF Activities ____ 4
E.S.3. Overview of Source and Sink Category Emission Estimates and Trends ____ 4
3.1. GHG Inventory ____ 4
3.2. KP-LULUCF Activities ____ 6
E.S.4. Other Information (Indirect GHGs and SO_2) ____ 6

CHAPTER 1. INTRODUCTION ____ 1-1
1.1. Background Information on Japan's Greenhouse Gas Inventory ____ 1-1
1.2. A Description of Japan's Institutional Arrangement for the Inventory Preparation ____ 1-1
1.3. Brief Description of the Inventory Preparation Process ____ 1-2
1.3.1. Annual cycle of the inventory preparation ____ 1-2
1.3.2. Process of the inventory preparation ____ 1-3
1.4. Brief General Description of Methodologies and Data Sources Used ____ 1-4
1.5. Brief Description of Key Categories ____ 1-5
1.5.1. GHG Inventory ____ 1-5
1.5.2. KP-LULUCF Activity ____ 1-7
1.6. Information on the QA/QC Plan including Verification and Treatment of Confidentiality Issues ____ 1-7
1.7. General Uncertainty Assessment, including Data on the Overall Uncertainty for the Inventory Totals ____ 1-8
1.7.1. GHG Inventory ____ 1-8
1.7.2. KP-LULUCF Activity ____ 1-8
1.8. General Assessment of the Completeness ____ 1-9

CHAPTER 2. TRENDS IN GHGS EMISSIONS AND REMOVALS ____ 2-1
2.1. Description and Interpretation of Emission and Removal Trends for Aggregate GHGs ____ 2-1
2.1.1. GHGs Emissions and Removals ____ 2-1
2.1.2. CO_2 Emissions per Capita ____ 2-3
2.1.3. CO_2 Emissions per Unit of GDP ____ 2-3
2.2. Description and Interpretation of Emission and Removal Trends by Gas ____ 2-4
2.2.1. CO_2 ____ 2-4
2.2.2. CH_4 ____ 2-6
2.2.3. N_2O ____ 2-7
2.2.4. HFCs ____ 2-8

2.2.5. PFCs 2-9
2.2.6. SF_6 2-10
2.3. Description and Interpretation of Emission and Removal Trends by Categories 2-10
2.3.1. Energy 2-12
2.3.2. Industrial Processes 2-12
2.3.3. Solvent and Other Product Use 2-14
2.3.4. Agriculture 2-14
2.3.5. Land Use, Land Use Change and Forestry (LULUCF) 2-15
2.3.6. Waste 2-16
2.4. Description and Interpretation of Emission Trends for Indirect GHGs and SO_2 2-17
2.5. Emissions and removals from KP-LULUCF activities 2-18

CHAPTER 3. ENERGY (CRF SECTOR 1) 3-1
3.1. Overview of Sector 3-1
3.2. Fuel Combustion (1.A.) 3-1
3.2.1. CO_2 Emissions from Energy Industries (1.A.1.:CO_2) 3-3
3.2.2. CH_4 and N_2O Emissions from Energy Industry (1.A.1.:CH_4, N_2O) 3-15
3.2.3. CO_2 Emissions from Manufacturing Industries and Construction (1.A.2.:CO_2) 3-23
3.2.4. CH_4 and N_2O Emissions from Manufacturing Industries and Construction (1.A.2.:CH_4, N_2O) 3-26
3.2.5. CO_2 Emissions from Transport (Mobile Combustion) (1.A.3.:CO_2) 3-27
3.2.6. CH_4 and N_2O Emissions from Transport (Mobile Combustion) (1.A.3.:CH_4 , N_2O) 3-30
3.2.6.1. Civil Aviation (1.A.3.a.) 3-30
3.2.6.2. Road Transportation (1.A.3.b.) 3-32
3.2.6.3. Railways (1.A.3.c.) 3-40
3.2.6.4. Navigation (1.A.3.d.) 3-42
3.2.7. CO_2 Emissions from Other Sectors (1.A.4.:CO_2) 3-43
3.2.8. CH_4 and N_2O Emissions from Other Sectors (1.A.4.:CH_4 and N_2O) 3-45
3.2.9. Comparison of Sectoral and Reference Approaches 3-47
3.2.10. International Bunker Fuels 3-47
3.2.11. Feedstocks and Non-Energy Use of Fuels 3-50
3.2.12. CO_2 capture from flue gases and subsequent CO_2 storage 3-52
3.2.13. Emission from waste incineration with energy recovery 3-52
3.3. Fugitive Emissions from Fuels (1.B.) 3-55
3.3.1. Solid Fuels (1.B.1.) 3-55
3.3.1.1. Coal Mining and Handling (1.B.1.a.) 3-55
3.3.1.2. Solid Fuel Transformation (1.B.1.b.) 3-60
3.3.2. Oil and Natural Gas (1.B.2.) 3-60
3.3.2.1. Oil (1.B.2.a.) 3-60
3.3.2.2. Natural Gas (1.B.2.b.) 3-67
3.3.2.3. Venting and Flaring (1.B.2.c.) 3-76

CHAPTER 4. INDUSTRIAL PROCESSES (CRF SECTOR 2) 4-1
4.1. Overview of Sector 4-1
4.2. Mineral Products (2.A.) 4-3
4.2.1. Cement Production (2.A.1.) 4-3
4.2.2. Lime Production (2.A.2.) 4-6
4.2.3. Limestone and Dolomite Use (2.A.3.) 4-8
4.2.4. Soda Ash Production and Use (2.A.4.) 4-11
4.2.4.1. Soda Ash Production (2.A.4.-) 4-11
4.2.4.2. Soda Ash Use (2.A.4.-) 4-12
4.2.5. Asphalt Roofing (2.A.5.) 4-13
4.2.6. Road Paving with Asphalt (2.A.6.) 4-13
4.3. Chemical Industry (2.B.) 4-13
4.3.1. Ammonia Production (2.B.1.) 4-14
4.3.2. Nitric Acid Production (2.B.2.) 4-16
4.3.3. Adipic Acid Production (2.B.3.) 4-17
4.3.4. Carbide Production (2.B.4.) 4-19
4.3.4.1. Silicon Carbide Production (2.B.4.-) 4-19
4.3.4.2. Calcium Carbide Production and Use (2.B.4.-) 4-21
4.3.5. Other (2.B.5.) 4-22
4.3.5.1. Carbon Black Production (2.B.5.-) 4-22
4.3.5.2. Ethylene Production (2.B.5.-) 4-23
4.3.5.3. 1,2-Dichloroethane (2.B.5.-) 4-25
4.3.5.4. Styrene Production (2.B.5.-) 4-26
4.3.5.5. Methanol Production (2.B.5.-) 4-27
4.3.5.6. Coke Production (2.B.5.-) 4-28
4.4. Metal Production (2.C.) 4-30
4.4.1. Iron and Steel Production (2.C.1.) 4-31
4.4.1.1. Steel Production (2.C.1.-) 4-31
4.4.1.2. Pig Iron Production (2.C.1.-) 4-31
4.4.1.3. Sinter Production (2.C.1.-) 4-31
4.4.1.4. Coke Production in Iron and Steel Production (2.C.1.-) 4-32
4.4.1.5. Use of Electric Arc Furnaces in Steel Production (2.C.1.-) 4-32
4.4.2. Ferroalloys Production (2.C.2.) 4-34
4.4.3. Aluminum Production (2.C.3.) 4-35
4.4.4. SF_6 Used in Aluminum and Magnesium Foundries (2.C.4.) 4-37
4.4.4.1. Aluminum Foundry 4-37
4.4.4.2. Magnesium Foundry 4-37
4.5. Other Production (2.D.) 4-38
4.5.1. Pulp and Paper (2.D.1.) 4-38
4.5.2. Food and Drink (2.D.2.) 4-38
4.6. Production of Halocarbons and SF_6 (2.E.) 4-38
4.6.1. By-product Emissions: Production of HCFC-22 (2.E.1.) 4-39
4.6.2. Fugitive Emissions (2.E.2.) 4-40
4.7. Consumption of Halocarbons and SF_6 (2.F.) 4-42
4.7.1. Refrigeration and Air Conditioning Equipment (2.F.1.) 4-43

4.7.1.1. Domestic Refrigeration Production, Use and Disposal (2.F.1.-) 4-43
4.7.1.2. Commercial Refrigeration Production, Use and Disposal (2.F.1.-) 4-45
4.7.1.3. Transport Refrigeration Production, Use and Disposal (2.F.1.-) 4-49
4.7.1.4. Industrial Refrigeration Production, Use and Disposal (2.F.1.-) 4-49
4.7.1.5. Stationary Air-Conditioning (Household) Production, Use and Disposal (2.F.1.-) 4-49
4.7.1.6. Mobile Air-Conditioning (Car Air Conditioners) Production, Use and Disposal (2.F.1.-) 4-51
4.7.2. Foam Blowing (2.F.2.) 4-53
4.7.2.1. Hard Foam Production (2.F.2.-) 4-53
4.7.2.2. Soft Foam (2.F.2.-) 4-57
4.7.3. Fire Extinguishers (2.F.3.) 4-57
4.7.4. Aerosols (2.F.4.) 4-58
4.7.4.1. Aerosols (2.F.4.-) 4-58
4.7.4.2. Metered Dose Inhalers (2.F.4.-) 4-60
4.7.5. Solvents (2.F.5.) 4-62
4.7.6. Other applications using ODS substitutes (2.F.6.) 4-63
4.7.7. Semiconductors Manufacture (2.F.7.) 4-63
4.7.7.1. Semiconductors (2.F.7.-) 4-63
4.7.7.2. Liquid Crystals (2.F.7.-) 4-65
4.7.8. Electrical Equipment (2.F.8.) 4-66
4.7.9. Other - Railway Silicon Rectifiers (2.F.9.) 4-68
4.7.10. Potential Emissions (2.F.P.) 4-69

CHAPTER 5. SOLVENT AND OTHER PRODUCT USE (CRF SECTOR 3) 5-1
5.1. Overview of Sector 5-1
5.2. Paint Application (3.A.) 5-1
5.3. Degreasing and Dry-Cleaning (3.B.) 5-1
5.4. Chemical Products, Manufacture and Processing (3.C.) 5-1
5.5. Other (3.D.) 5-2
5.5.1. Use of Nitrous Oxide for Anesthesia (3.D.1.) 5-2
5.5.2. N_2O from Fire Extinguishers (3.D.2) 5-3
5.5.3. N_2O from Aerosol Cans (3.D.-) 5-4

CHAPTER 6. AGRICULTURE (CRF SECTOR 4) 6-1
6.1. Overview of Sector 6-1
6.2. Enteric Fermentation (4.A.) 6-1
6.2.1. Cattle (4.A.1.) 6-2
6.2.2. Buffalo, Sheep, Goats, Horses & Swine (4.A.2., 4.A.3., 4.A.4., 4.A.6., 4.A.8.) 6-7
6.2.3. Poultry (4.A.9.) 6-9
6.2.4. Camels and Llamas, Mules and Asses (4.A.5., 4.A.7.) 6-9
6.2.5. Other (4.A.10.) 6-9
6.3. Manure Management (4.B.) 6-9
6.3.1. Cattle, Swine and Poultry (4.B.1., 4.B.8., 4.B.9.) 6-10

6.3.2. Buffalo, Sheep, Goats & Horses (4.B.2., 4.B.3., 4.B.4., 4.B.6.) 6-20
6.3.3. Camels and Llamas, Mules and Asses (4.B.5., 4.B.7.) 6-22
6.3.4. Other (4.B.10.) 6-22
6.4. Rice Cultivation (4.C.) 6-22
6.4.1. Intermittently Flooded (Single Aeration) (4.C.1.-) 6-23
6.4.2. Continuously Flooded (4.C.1.-) 6-26
6.4.3. Rainfed & Deep Water (4.C.2., 4.C.3.) 6-27
6.4.4. Other (4.C.4.) 6-27
6.5. Agricultural Soils (4.D.) 6-27
6.5.1. Direct Soil Emissions (4.D.1.) 6-28
6.5.1.1. Synthetic Fertilizers (4.D.1.-) 6-28
6.5.1.2. Organic Fertilizer (Application of Animal Waste) (4.D.1.-) 6-32
6.5.1.3. N-fixing Crops (4.D.1.-) 6-34
6.5.1.4. Crop Residue (4.D.1.-) 6-36
6.5.1.5. Plowing of Organic Soil (4.D.1.-) 6-40
6.5.1.6. Direct Emissions (CH_4) 6-42
6.5.2. Pasture, Range and Paddock Manure (4.D.2.) 6-42
6.5.3. Indirect Emissions (4.D.3.) 6-42
6.5.3.1. Atmospheric Deposition (4.D.3.-) 6-42
6.5.3.2. Nitrogen Leaching and Run-off (4.D.3.-) 6-47
6.5.3.3. Indirect Emissions (CH_4) (4.D.3.-) 6-48
6.5.4. Other (4.D.4) 6-48
6.6. Prescribed Burning of Savannas (4.E.) 6-48
6.7. Field Burning of Agricultural Residues (4.F.) 6-48
6.7.1. Rice, Wheat, Barley, Rye, and Oats (4.F.1.) 6-49
6.7.2. Maize, Peas, Soybeans, Adzuki beans, Kidney beans, Peanuts, Potatoes, Sugarbeets & Sugar cane (4.F.1., 4.F.2., 4.F.3., 4.F.4.) 6-53
6.7.3. Dry bean (4.F.2.-) 6-55
6.7.4. Other (4.F.5.) 6-55

CHAPTER 7. LAND USE, LAND-USE CHANGE AND FORESTRY (CRF SECTOR 5) 7-1
7.1. Overview of Sector 7-1
7.2. Method of determining land-use categories 7-2
7.2.1. Basic approach 7-2
7.2.2. Methods of determining land-use categories and areas 7-3
7.2.3. Survey methods and due dates of major land area statistics 7-5
7.2.4. Land area estimation methods 7-5
7.3. Parameters for estimating carbon stock changes from land use conversions 7-7
7.4. Forest land (5.A.) 7-9
7.4.1. Forest land remaining Forest land (5.A.1.) 7-10
7.4.2. Land converted to Forest land (5.A.2) 7-21
7.5. Cropland (5.B) 7-25
7.5.1. Cropland remaining Cropland (5.B.1) 7-26
7.5.2. Land converted to Cropland (5.B.2) 7-30
7.6. Grassland (5.C) 7-37

7.6.1. Grassland remaining Grassland (5.C.1) 7-38
7.6.2. Land converted to Grassland (5.C.2) 7-39
7.7. Wetlands (5.D) 7-44
7.7.1. Wetlands remaining Wetlands (5.D.1) 7-45
7.7.2. Land converted to Wetlands (5.D.2) 7-45
7.8. Settlements (5.E) 7-49
7.8.1. Settlements remaining Settlements (5.E.1) 7-50
7.8.2. Land converted to Settlements (5.E.2) 7-56
7.9. Other land (5.F) 7-63
7.9.1. Other land remaining Other land (5.F.1) 7-63
7.9.2. Land converted to Other land (5.F.2) 7-64
7.10. Direct N_2O emissions from N fertilization (5. (I)) 7-68
7.11. N_2O emissions from drainage of soils (5.(II)) 7-69
7.12. N_2O emissions from disturbance associated with land-use conversion to Cropland (5.(III)) 7-69
7.13. CO_2 emissions from agricultural lime application (5.(IV)) 7-71
7.14. Biomass burning (5.(V)) 7-73

CHAPTER 8. WASTE (CRF SECTOR 6) 8-1
8.1. Overview of Sector 8-1
8.1.1. Overview of Waste Management and Estimation Category 8-1
8.1.2. Overview of Greenhouse Gas Emissions on Waste Sector 8-2
8.1.3. General Recalculations for Emissions from Waste Sector 8-3
8.2. Solid Waste Disposal on Land (6.A.) 8-3
8.2.1. Emissions from Managed Landfill Sites (6.A.1.) 8-5
8.2.2. Emissions from Unmanaged Waste Disposal Sites (6.A.2.) 8-16
8.2.3. Emissions from Other Managed Landfill Sites (6.A.3.) 8-16
8.2.3.1. Emissions from Inappropriate Disposal (6.A.3.a) 8-16
8.3. Wastewater Handling (6.B.) 8-17
8.3.1. Industrial Wastewater (6.B.1.) 8-19
8.3.1.1. Industrial Wastewater (6.B.1.a) 8-19
8.3.1.2. Landfill Leachate Treatment (6.B.1.b) 8-23
8.3.2. Domestic and Commercial Wastewater (6.B.2.) 8-26
8.3.2.1. Sewage Treatment Plant (6.B.2.a) 8-26
8.3.2.2. Domestic Sewage Treatment Plant (Mainly Septic Tanks) (6.B.2.b) 8-28
8.3.2.3. Human-Waste Treatment Plant (6.B.2.c) 8-32
8.3.2.4. Emission from the Natural Decomposition of Domestic Wastewater (6.B.2.d) 8-36
8.3.2.5. Recovery of CH_4 Emitted from Treating Domestic and Commercial Wastewater (Reference Value) (6.B.2.-) 8-39
8.4. Waste Incineration (6.C.) 8-42
8.4.1. Waste Incineration without Energy Recovery (6.C.) 8-45
8.4.1.1. Municipal Solid Waste Incineration (6.C.1) 8-45
8.4.1.2. Industrial Waste Incineration (6.C.2) 8-53
8.4.1.3. Incineration of Specially controlled Industrial Waste (6.C.3) 8-60
8.4.2. Emissions from Waste Incineration with Energy Recovery (1.A.) 8-63

8.4.3. Emissions from Direct Use of Waste as Fuel (1.A.) 8-65
8.4.3.1. Emissions from Municipal Waste (Plastics) Used as Alternative Fuel (1.A.1 and 1.A.2) 8-70
8.4.3.2. Emissions from Industrial Waste (Plastics, Waste Oil, and Wood) Used as Raw Material or Alternative Fuels (1.A.2.)) 8-73
8.4.3.3. Emissions from Waste Tires Used as Raw Materials and Alternative Fuels (1.A.1 and 1.A.2) 8-76
8.4.4. Emissions from Incineration of Waste Processed as Fuel (1.A.) 8-77
8.4.4.1. Incineration of Refuse-based Solid Fuels (RDF and RPF) (1.A.1 and 1.A.2) 8-77
8.5. Other (6.D.) 8-84
8.5.1. Emissions from Composting of Organic Waste (6.D.1) 8-84
8.5.2. Emissions from the Decomposition of Petroleum-Derived Surfactants (6.D.2) 8-86

CHAPTER 9. OTHER (CRF SECTOR 7) 9-1
9.1. Overview of Sector 9-1
9.2. CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 9-1
9.3. NOx, CO, NMVOC, and SO_2 9-1

CHAPTER 10. RECALCULATION AND IMPROVEMENTS 10-1
10.1. Explanation and Justification for Recalculations 10-1
10.1.1. General Issues 10-1
10.1.2. Recalculations in Each Sector 10-1
10.2. Implications for Emission Levels 10-1
10.2.1. GHG Inventory 10-1
10.2.2. KP-LULUCF Inventory 10-5
10.3. Implication for Emission Trends, including Time Series Consistency 10-6
10.3.1. GHG Inventory 10-6
10.4. Recalculations and improvement plan, including response to the review process 10-7
10.4.1. Improvements after submission of inventory 10-7
10.4.1.1. Methodology for estimating emissions and removals of GHGs 10-7
10.4.1.2. National Greenhouse Gas Inventory Report 10-10
10.4.1.3. Improvements by following UNFCCC-ERT recommendations 10-10
10.4.2. Planned Improvements 10-18

CHAPTER 11. SUPPLEMENTARY INFORMATION ON LULUCF ACTIVITIES UNDER ARTICLE 3, PARAGRAPHS 3 AND 4 OF THE KYOTO PROTOCOL 11-1
11.1. Summary of removal related trends, and emissions and removals from KP LULUCF activities 11-1
11.2. General information 11-2
11.2.1. Definition of forest and any other criteria 11-2
11.2.2. Elected activities under Article 3, paragraph 4 of the Kyoto Protocol 11-3
11.2.2.1. Forest Management 11-3
11.2.2.2. Revegetation 11-3

11.2.3. 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 ____ 11-4
11.2.4. 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 ____ 11-4
11.3. Land-related information ____ 11-4
11.3.1. Spatial assessment unit used for determining the area of the units of land under Article 3.3 ____ 11-4
11.3.2. Methodology used to develop the land transition matrix ____ 11-4
11.3.2.1. Description of land transition matrix (CRF-NIR Table 2) ____ 11-4
11.3.2.2. Overview of the procedures to estimate emissions and removals ____ 11-4
11.3.2.3. Afforestation/Reforestation and Deforestation ____ 11-5
11.3.2.4. Forest Management ____ 11-7
11.3.2.5. Revegetation ____ 11-10
11.3.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations ____ 11-14
11.4. Activity-specific information ____ 11-16
11.4.1. Methods for carbon stock change and GHG emission and removal estimates ____ 11-16
11.4.1.1. Description of the methodologies and the underlying assumptions used ____ 11-16
11.4.1.2. Justification when omitting any carbon pool or GHG emissions/removals from activities under Article 3.3 and elected activities under Article 3.4 ____ 11-40
11.4.1.3. Information on whether or not indirect and natural GHG emissions and removals have been factored out ____ 11-40
11.4.1.4. Changes in data and methods since the previous submission (recalculations) ____ 11-40
11.4.1.5. Uncertainty estimates ____ 11-41
11.4.1.6. Information on other methodological issues (methods dealing with the effects of natural disturbances) ____ 11-44
11.4.1.7. The year of the onset of an activity, if after 2008 ____ 11-45
11.5. Article 3.3 ____ 11-45
11.5.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 and are direct human-induced ____ 11-45
11.5.2. Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation ____ 11-46
11.5.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested ____ 11-46
11.5.4. Information on emissions and removals of greenhouse gases from lands harvested during the first commitment period following afforestation and reforestation ____ 11-46
11.6. Article 3.4 ____ 11-46
11.6.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced ____ 11-46

11.6.1.1. Forest Management 11-46
11.6.1.2. Revegetation 11-47
11.6.2. Information relating to Revegetation for the base year and the commitment period 11-48
11.6.3. 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 11-48
11.6.4. Information relating to Forest Management 11-49
11.6.4.1. The definition of forest for this category conforms with the definition in item 11.2 above 11-49
11.6.4.2. The definition of forest management conforms with the definition in paragraph 1 (f) of the Annex to decision 16/CMP.1 11-49
11.6.4.3. Information on the extent to which GHG removals by sinks offset the debit incurred under Article 3.3. 11-49
11.7. Other information 11-49
11.7.1. Key category analysis for Article 3.3 activities and any elected activities under Article3.4 11-49
11.7.2. Further improvements 11-50
11.8. Information relating to Article 6 11-51
11.9. Information on the reporting status of paragraphs 5 to 9 of the Annex to decision 15/CMP.1 11-51

CHAPTER 12. INFORMATION ON ACCOUNTING OF KYOTO UNITS 12-1
12.1. Summary of information reported in the SEF tables 12-1
12.2. Discrepancies and notifications 12-1
12.3. Publicly accessible information 12-2
12.4. Calculation of the commitment period reserve (CPR) 12-2
12.5. KP-LULUCF accounting 12-2

CHAPTER 13. INFORMATION ON CHANGES IN NATIONAL SYSTEM 13-1

CHAPTER 14. INFORMATION ON CHANGES IN NATIONAL REGISTRY 14-1
14.1. Summary of changes made on national registry of Japan in 2013 14-1
14.2. Information relevant to the changes made on national registry of Japan 14-2

CHAPTER 15. INFORMATION ON MINIMIZATION OF ADVERSE IMPACTS IN ACCORDANCE WITH ARTICLE 3, PARAGRAPH 14 15-1
15.1. Overview 15-1
15.2. Actions to minimize adverse impacts in accordance with Article 3, paragraph 14 15-1

ANNEX 1. KEY CATEGORIES A 1-1
A1.1. Outline of Key Category Analysis A 1-1
A1.2. Results of Key Category Analysis A 1-1

ANNEX 2. DETAILED DISCUSSION ON METHODOLOGY AND DATA FOR ESTIMATING CO_2 EMISSIONS FROM FOSSIL FUEL COMBUSTION ____ A 2-1
A2.1. Discrepancies between the figures reported in the CRF tables and the IEA statistics ____ A 2-1
A2.2. General Energy Statistics ____ A 2-11
A2.3. Quality Standard for Diesel Oil ____ A 2-24

ANNEX 3. OTHER DETAILED METHODOLOGICAL DESCRIPTIONS FOR INDIVIDUAL SOURCE OR SINK CATEGORIES ____ A 3-1
A3.1. Additional Information for CH_4 and N_2O Emissions from Stationary Combustion (1.A.1., 1.A.2. and 1.A.4.) ____ A 3-1
A3.1.1. Summary of Emission Factors ____ A 3-1
A3.1.2. Calculation of Emission Factors by Fuel Type ____ A 3-3
A3.1.3. Emission Factors with Air-Intake Adjustment ____ A 3-9
A3.1.4. Confirmation of the Validity of the Emission Factors of Fuel Combustion ____ A 3-11
A3.2. Methodology for Estimating Emissions of Precursors ____ A 3-12
A3.2.1. Energy Sector ____ A 3-12
A3.2.2. Industrial Processes ____ A 3-24
A3.2.3. Sectors that use solvents and other products ____ A 3-27
A3.2.4. Agriculture ____ A 3-31
A3.2.5. Land Use, Land-Use Change and Forestry ____ A 3-33
A3.2.6. Wastes ____ A 3-33
A3.2.7. Other sectors ____ A 3-38

ANNEX 4. CO_2 REFERENCE APPROACH AND COMPARISON WITH SECTORAL APPROACH, AND RELEVANT INFORMATION ON THE NATIONAL ENERGY BALANCE ____ A 4-1
A4.1. Difference in Energy Consumption ____ A 4-1
A4.2. Difference in CO_2 Emissions ____ A 4-2
A4.3. Comparison between Differences in Energy Consumption and that of CO_2 Emissions ____ A 4-3
A4.4. Causes of the difference between Reference Approach and Sectoral Approach ____ A 4-3

ANNEX 5. ASSESSMENT OF COMPLETENESS AND (POTENTIAL) SOURCES AND SINKS OF GREENHOUSE GAS EMISSIONS AND REMOVALS EXCLUDED ____ A 5-1
A5.1. Assessment of Completeness ____ A 5-1
A5.2. Definition of Notation Keys ____ A 5-1
A5.3. Decision Tree for Application of Notation Keys ____ A 5-3
A5.4. Source categories not estimated in Japan's inventory ____ A 5-3

ANNEX 6. ADDITIONAL INFORMATION TO BE CONSIDERED AS PART OF THE NIR SUBMISSION OR OTHER USEFUL REFERENCE INFORMATION ____ A 6-1
A6.1. Details on Inventory Compilation System and QA/QC Plan ____ A 6-1
A6.1.1. Introduction to QA/QC Plan ____ A 6-1
A6.1.2. QA/QC plan's scope ____ A 6-1
A6.1.3. Roles and responsibilities of each entity involved in the inventory preparation process ____ A 6-1

A6.1.4. Collection process of activity data ____ A 6-3
A6.1.5. Selection process of emission factors and estimation methods ____ A 6-3
A6.1.6. Improvement process of estimations for emissions and removals ____ A 6-4
A6.1.7. QA/QC activity ____ A 6-4
A6.1.8. Response for UNFCCC inventory review ____ A 6-8
A6.1.9. Documentation and archiving of inventory information ____ A 6-9

ANNEX 7. METHODOLOGY AND RESULTS OF UNCERTAINTY ASSESSMENT ____ A 7-1
A7.1. Methodology of Uncertainty Assessment ____ A 7-1
A7.1.1. Background and Purpose ____ A 7-1
A7.1.2. Overview of Uncertainty Assessment Indicated in the Good Practice Guidance ____ A 7-1
A7.1.3. Methodology of Uncertainty Assessment in Japan's Inventories ____ A 7-3
A7.2. Results of Uncertainty Assessment ____ A 7-16
A7.2.1. Assumption of Uncertainty Assessment ____ A 7-16
A7.2.2. Uncertainty of Japan's Total Emissions ____ A 7-16
A7.2.3. Energy Sector ____ A 7-16
A7.2.4. Industrial Processes ____ A 7-18
A7.2.5. Solvents and Other Product Use ____ A 7-20
A7.2.6. Agriculture ____ A 7-20
A7.2.7. LULUCF ____ A 7-21
A7.2.8. Waste ____ A 7-21
A7.2.9. Consideration of the results ____ A 7-22
A7.2.10. Issues in Uncertainty Assessment ____ A 7-22
A7.2.11. Reference Material ____ A 7-23

ANNEX 8. HIERARCHICAL STRUCTURE OF JAPAN'S NATIONAL GHG INVENTORY FILE SYSTEM ____ A 8-1

ANNEX 9. SUMMARY OF COMMON REPORTING FORMAT ____ A 9-1

Abbreviations

Executive Summary of National GHGs Inventory Report of Japan 2014

E.S.1. Background Information on GHGs Inventories, Climate Change and Supplementary Information Required under Article 7, Paragraph 1, of the Kyoto Protocol

This national inventory report comprises the inventory of the emissions and removals of greenhouse gases (GHGs), indirect GHGs and SO_2 in Japan for FY1990 through to FY2012[1], on the basis of Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and supplementary information for FY2008 through to FY2012 required under Article 7, Paragraph 1 of the Kyoto Protocol.

Japan's estimation methodologies of GHGs inventories are in line with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereafter, *Revised 1996 IPCC Guidelines*) which was developed by the Intergovernmental Panel on Climate Change (IPCC). In addition, the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)* (hereafter, *GPG (2000)*) and the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereafter, *GPG-LULUCF*) are applied to improve transparency, consistency, comparability, completeness and accuracy of the inventory.

Annual inventory is reported in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (FCCC/SBSTA/2006/9) adopted by the Conference of the Parties. Supplementary information under Article 7, Paragraph 1 of the Kyoto Protocol is reported in accordance with *Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol* prepared by the UNFCCC secretariat.

[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, and Emission and Removals from KP-LULUCF Activities

2.1. GHG Inventory

Total GHGs emissions in FY2012[2] (excluding LULUCF) were 1,343 million tonnes (in CO_2 eq.). They increased by 8.8% compared to the emissions in FY1990[3] (excluding LULUCF). Compared to the emissions in the base year under the Kyoto Protocol[4], they increased by 6.5%.

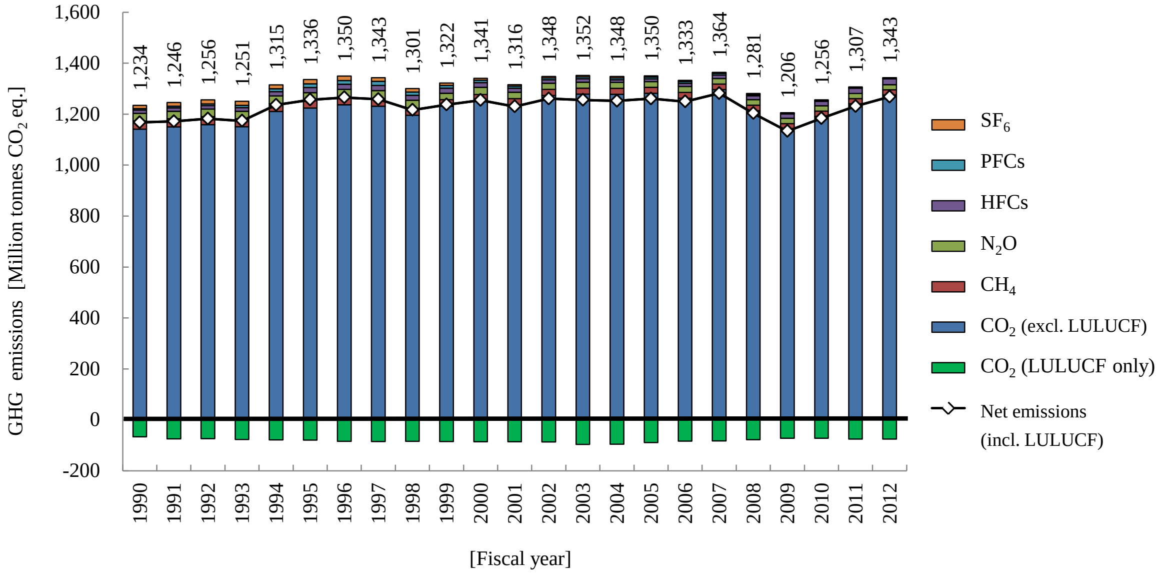

Figure 1 Trends in GHGs emission and removals in Japan

[2] The sum of CO_2, CH_4, N_2O, HFCs, PFCs and SF_6 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 *Second Assessment Report* (1995) issued by the IPCC.

[3] The sum of CO_2, CH_4 and N_2O emissions converted to CO_2 equivalents multiplied by their respective GWP.

[4] Japan's base year under the Kyoto Protocol for CO_2, CH_4, N_2O emissions is FY1990, while CY1995 is the base year for HFCs, PFCs, and SF_6 emissions.

Table 1 Trends in GHGs emission and removals in Japan

[Million tonnes CO_2 eq.]	GWP	KPBY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (excl. LULUCF)	1	1,144.1	1,141.1	1,150.1	1,158.5	1,150.9	1,210.7	1,223.7	1,236.6	1,231.5	1,195.9	1,230.8
CO_2 (incl. LULUCF)	1	NA	1,074.2	1,075.8	1,084.5	1,073.7	1,131.6	1,144.2	1,152.3	1,146.7	1,111.2	1,145.9
CO_2 (LULUCF only)	1	NA	-66.9	-74.3	-74.1	-77.2	-79.0	-79.5	-84.3	-84.8	-84.6	-84.9
CH_4 (excl. LULUCF)	21	33.4	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6
CH_4 (incl. LULUCF)	21	NA	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6
N_2O (excl. LULUCF)	310	32.6	29.7	29.3	29.5	29.3	30.6	31.0	32.1	32.8	31.3	24.9
N_2O (incl. LULUCF)	310	NA	29.8	29.3	29.5	29.4	30.6	31.1	32.1	32.8	31.3	24.9
HFCs	HFC-134a: 1,300 etc.	20.2	12.6	13.7	14.1	14.4	16.8	20.3	19.9	19.9	19.4	19.9
PFCs	PFC-14: 6,500 etc.	14.0	5.3	6.1	6.2	8.9	10.9	14.3	14.8	16.2	13.4	10.4
SF_6	23,900	16.9	13.2	14.7	16.2	16.2	15.4	17.0	17.5	15.0	13.6	9.3
Gross total (excl. LULUCF)		1,261.3	1,234.3	1,245.8	1,256.1	1,250.8	1,314.8	1,335.9	1,349.7	1,343.3	1,300.7	1,321.9
Net total (incl. LULUCF)		NA	1,167.5	1,171.6	1,182.1	1,173.7	1,235.9	1,256.5	1,265.5	1,258.6	1,216.1	1,237.0

[Million tonnes CO_2 eq.]	GWP		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (excl. LULUCF)	1		1,251.5	1,236.3	1,273.4	1,278.5	1,277.9	1,282.1	1,263.0	1,296.2	1,213.8	1,141.5
CO_2 (incl. LULUCF)	1		1,165.8	1,150.5	1,186.3	1,182.3	1,182.1	1,192.8	1,179.7	1,213.7	1,136.3	1,068.9
CO_2 (LULUCF only)	1		-85.7	-85.9	-87.1	-96.2	-95.8	-89.4	-83.3	-82.4	-77.5	-72.5
CH_4 (excl. LULUCF)	21		26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1
CH_4 (incl. LULUCF)	21		26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1
N_2O (excl. LULUCF)	310		27.5	24.2	23.5	23.3	23.4	23.0	23.0	21.8	21.7	21.4
N_2O (incl. LULUCF)	310		27.5	24.2	23.6	23.3	23.4	23.0	23.0	21.9	21.7	21.5
HFCs	HFC-134a: 1,300 etc.		18.8	16.2	13.7	13.8	10.6	10.5	11.7	13.3	15.3	16.5
PFCs	PFC-14: 6,500 etc.		9.6	8.0	7.4	7.2	7.5	7.0	7.3	6.4	4.6	3.3
SF_6	23,900		7.2	6.0	5.6	5.3	5.1	4.8	4.9	4.4	3.8	1.9
Gross total (excl. LULUCF)			1,340.5	1,315.7	1,347.8	1,351.7	1,347.6	1,350.3	1,332.5	1,364.3	1,280.9	1,205.7
Net total (incl. LULUCF)			1,254.9	1,229.8	1,260.8	1,255.5	1,251.9	1,261.0	1,249.2	1,281.8	1,203.4	1,133.2

[Million tonnes CO_2 eq.]	GWP		2010	2011	2012	Changes in emissions/removals (2012)		
						KPBY	1990	Previous year
CO_2 (excl. LULUCF)	1		1,191.1	1,240.6	1,275.6	11.5%	11.8%	2.8%
CO_2 (incl. LULUCF)	1		1,118.7	1,165.0	1,200.5	-	11.8%	3.0%
CO_2 (LULUCF only)	1		-72.4	-75.6	-75.1	-	12.2%	-0.7%
CH_4 (excl. LULUCF)	21		20.7	20.3	20.0	-40.1%	-38.3%	-1.4%
CH_4 (incl. LULUCF)	21		20.7	20.3	20.0	-	-38.3%	-1.4%
N_2O (excl. LULUCF)	310		20.8	20.5	20.2	-38.0%	-31.9%	-1.3%
N_2O (incl. LULUCF)	310		20.8	20.5	20.2	-	-32.1%	-1.3%
HFCs	HFC-134a: 1,300 etc.		18.3	20.5	22.9	13.4%	82.0%	12.1%
PFCs	PFC-14: 6,500 etc.		3.4	3.0	2.8	-80.4%	-47.7%	-8.6%
SF_6	23,900		1.9	1.6	1.6	-90.6%	-88.0%	-3.2%
Gross total (excl. LULUCF)			1,256.1	1,306.5	1,343.1	6.5%	8.8%	2.8%
Net total (incl. LULUCF)			1,183.7	1,230.9	1,268.1	-	8.6%	3.0%

* KPBY: Base year of Kyoto Protocol
* NA: Not applicable
* NE: Not estimated
* LULUCF: Land Use, Land-Use Change and Forestry
* CH_4 and N_2O emissions in Table 1 include emissions from LULUCF based on the estimation method decided by the UNFCCC. On the contrary, since emissions from LULUCF are regarded as RMU (removal unit) according to Article 3.3 of the Kyoto Protocol, they are not included in GHGs emissions based on Kyoto Protocol (refer annex 8 table 1).

2.2. KP-LULUCF Activities

Japan reports supplementary information on afforestation/reforestation (AR), deforestation (D), Forest management (FM) and revegetation (RV) as LULUCF activities under article 3, paragraphs 3 and 4 of the Kyoto Protocol. The breakdown of emissions and removals to each activity in the first commitment period of the Kyoto Protocol 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	Net emissions/removals						Accounting parameters	Accounting quantity
		2008	2009	2010	2011	2012	Total		
	(Gg CO_2 equivalent)								
A. Article 3.3 activities									
A.1. Afforestation and Reforestation									-2320.58
A.1.1. Units of land not harvested since the beginning of the commitment period		-426.28	-447.99	-469.67	-482.25	-494.39	-2,320.58		-2320.58
A.1.2. Units of land harvested since the beginning of the commitment period									
A.2. Deforestation		2,167.75	2,646.75	3,036.04	1,632.98	1,954.89	11,438.42		11438.42
B. Article 3.4 activities									
B.1. Forest management (if elected)		-46,363.73	-48,096.39	-50,931.50	-51,638.70	-53,140.34	-250,170.66		-247451.17
3.3 offset								9,117.84	-9117.84
FM cap								238,333.33	-238333.33
B.2. Cropland management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	-77.82	-1079.70	-1110.88	-1128.66	-1142.08	-1161.85	-5623.17	-389.12	-5234.05

※ Japan's actual net removals by FM after application of 3.3 offset for the first commitment period of the Kyoto Protocol exceeded the upper limit given to Japan in the appendix to decision 16/CMP.1, which was 13 Mt-C times 5 (238,333 Gg-CO_2). Therefore, Japan accounted for the removals by the upper limit.

※ Since the total anthropogenic GHG emissions by sources and removals by sinks in managed forests since 1990 are larger than the net source of emissions incurred under Article 3.3, the offset rule according to paragraph 10 of the annex to decision 16/CMP.1 is applied to Japan.

※ 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

3.1. GHG Inventory

The breakdown of GHGs emissions and removals in FY2012 by sector[5] shows that the energy accounts for 91.5% of total GHGs emissions. It is followed by the industrial processes (5.2%), the agriculture (1.8%), the waste (1.5%) and the solvents and other product use (0.01%).

Removals by the LULUCF in FY2012 were equivalent to 5.6% of total GHGs emissions.

[5] It implies "Category" indicated in the *Revised 1996 IPCC Guidelines* and CRF.

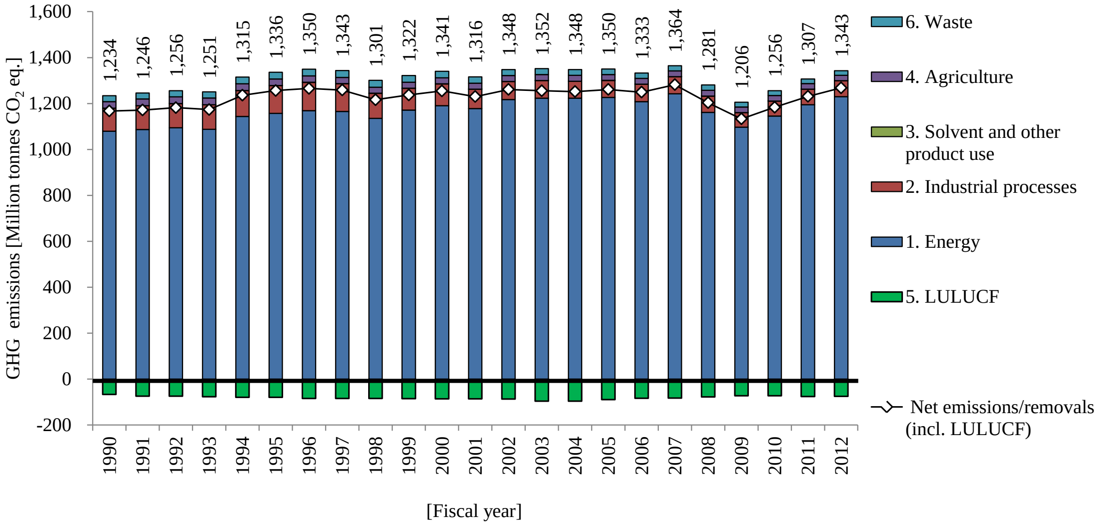

Figure 2 Trends in GHGs emissions and removals in each category

Table 3 Trends in GHGs emissions and removals in each category

[Million tonnes CO_2 eq.]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1. Energy	1,079.4	1,087.1	1,094.4	1,087.6	1,143.6	1,156.6	1,168.7	1,165.8	1,135.6	1,170.9
2. Industrial processes	99.5	103.3	105.2	107.0	113.0	121.4	123.4	120.1	108.6	95.2
3. Solvent and other product use	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4. Agriculture	29.1	29.1	29.1	29.1	28.7	28.2	27.5	26.9	26.5	26.2
5. LULUCF	-66.8	-74.2	-74.0	-77.1	-78.9	-79.4	-84.2	-84.7	-84.6	-84.9
6. Waste	25.9	25.9	27.0	26.6	29.1	29.3	29.6	30.0	29.7	29.2
Net emissions/removals (incl. LULUCF)	1,167.5	1,171.6	1,182.1	1,173.7	1,235.9	1,256.5	1,265.5	1,258.6	1,216.1	1,237.0
Emissions (excl. LULUCF)	1,234.3	1,245.8	1,256.1	1,250.8	1,314.8	1,335.9	1,349.7	1,343.3	1,300.7	1,321.9

[Million tonnes CO_2 eq.]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	1,190.8	1,177.9	1,217.7	1,223.3	1,223.1	1,226.8	1,208.2	1,242.2	1,161.5	1,096.9
2. Industrial processes	94.3	84.3	77.9	76.6	73.8	73.7	75.7	74.3	70.7	63.5
3. Solvent and other product use	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1
4. Agriculture	26.0	25.8	25.6	25.5	25.4	25.3	25.3	25.1	24.8	24.4
5. LULUCF	-85.6	-85.8	-87.0	-96.2	-95.8	-89.3	-83.3	-82.4	-77.5	-72.5
6. Waste	29.1	27.3	26.3	26.0	25.1	24.4	23.1	22.5	23.8	20.7
Net emissions/removals (incl. LULUCF)	1,254.9	1,229.8	1,260.8	1,255.5	1,251.9	1,261.0	1,249.2	1,281.8	1,203.4	1,133.2
Emissions (excl. LULUCF)	1,340.5	1,315.7	1,347.8	1,351.7	1,347.6	1,350.3	1,332.5	1,364.3	1,280.9	1,205.7

[Million tonnes CO_2 eq.]	2010	2011	2012
1. Energy	1,145.1	1,195.0	1,229.6
2. Industrial processes	65.8	67.2	69.5
3. Solvent and other product use	0.1	0.1	0.1
4. Agriculture	24.2	24.0	23.9
5. LULUCF	-72.4	-75.6	-75.1
6. Waste	20.9	20.2	20.0
Net emissions/removals (incl. LULUCF)	1,183.7	1,230.9	1,268.1
Emissions (excl. LULUCF)	1,256.1	1,306.5	1,343.1

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

3.2. KP-LULUCF Activities

See section 2.2 of executive summary.

E.S.4. Other Information (Indirect GHGs and SO_2)

Under the UNFCCC, it is required to report emissions not only 6 types of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) that are controlled by the Kyoto Protocol, but also emissions of indirect GHGs (NO_X, CO and NMVOC) as well as SO_2. Their emission trends are indicated below.

Nitrogen oxide (NO_X) emissions in FY2012 were 1,627 thousand tonnes. They decreased by 20.4% since FY1990 and by 2.9% compared to the previous year.

Carbon monoxide (CO) emissions in FY2012 were 2,502 thousand tonnes. They decreased by 44.2% since FY1990 and increased by 0.8% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY2012 were 1,538 thousand tonnes. They decrease by 20.9% since FY1990 and by 1.2% compared to the previous year.

Sulfur dioxide (SO_2) emissions in FY2012 were 937 thousand tonnes. They decreased by 25.3% since FY1990 and by 0.6% compared to the previous year.

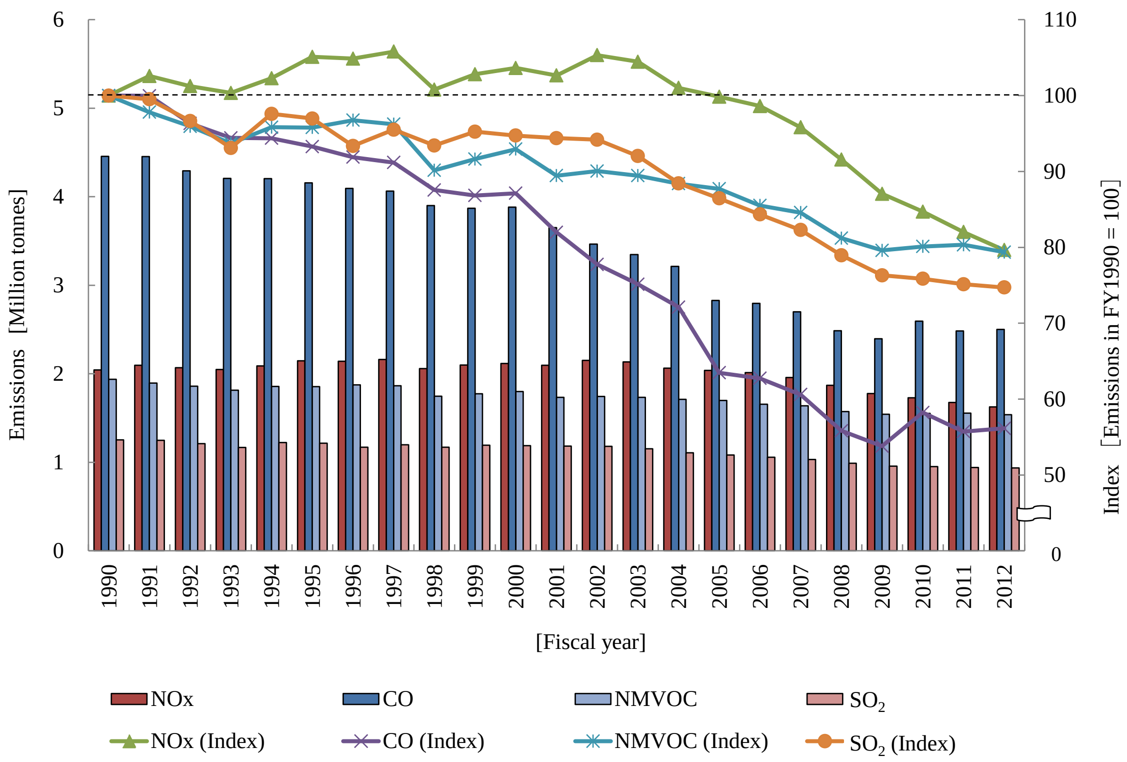

Figure 3 Trends in emissions of indirect GHGs and SO_2

Chapter 1. Introduction

1.1. Background Information on Japan's Greenhouse Gas Inventory

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 FY2012[1], on the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC) and of Article 7 of the Kyoto Protocol.

Estimation methodologies for the GHG inventories are required to be in line with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*Revised 1996 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 *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* published in 2000 (*GPG (2000))* and the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* published in 2003 (*GPG-LULUCF*).

Japan's national inventory is reported in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (FCCC/SBSTA/2006/9). For the reporting of supplementary information required under Article 7, paragraph 1 of the Kyoto Protocol, the reporting guidelines (*Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol*), the use of which is encouraged by the UNFCCC Secretariat, are applied.

1.2. A Description of Japan's Institutional Arrangement for the Inventory Preparation

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 Article 7.1, which is annually submitted to the Conference of the Parties through the UNFCCC Secretariat 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, the key category analysis and the uncertainty assessment 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 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 Article 7.1. The relevant ministries and agencies check and verify the inventories (i.e., CRF, NIR), including the spreadsheets that are actually utilized for the estimation, as a part of the

[1] "FY (fiscal year)" is used because the major part of CO_2 emission estimate is on the fiscal year basis (April to March).

Quality Control (QC) activities.

The checked and verified 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 each relevant ministry, agency and organization in the inventory preparation process is described in Annex 6.

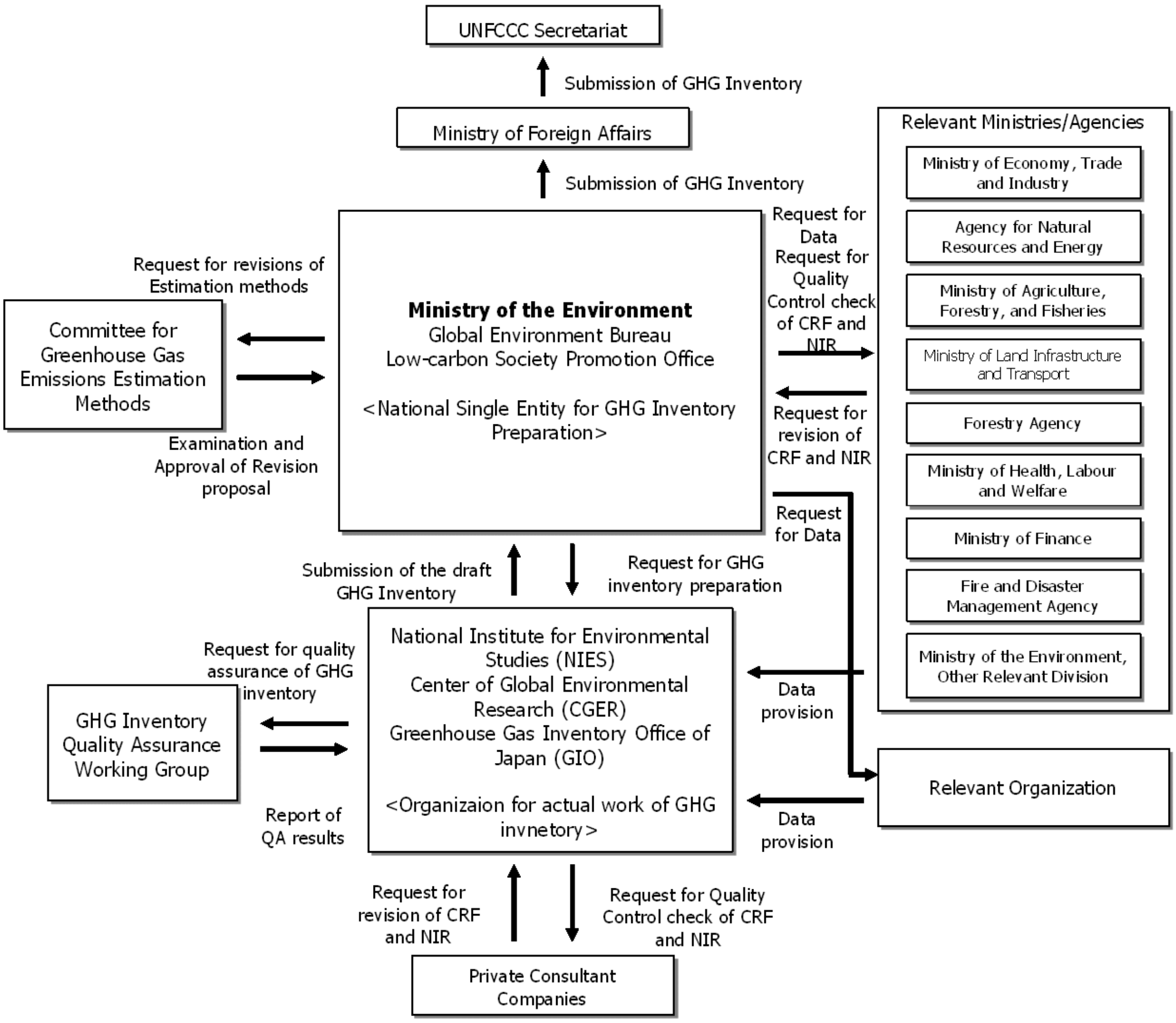

Figure 1-1 Japan's institutional arrangement for the national inventory preparation

1.3. Brief Description of the Inventory Preparation Process

1.3.1. Annual cycle of the inventory preparation

Table 1-1 shows the annual cycle of the inventory preparation. 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 1-1 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	➞	➞	➞	➞								

★: Inventory submission and official announcement must be implemented within 6 weeks after April 15.
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 (refer to Annex 6).

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

The data required for preparing the national inventory and the supplementary information required under Article 7.1 of the Kyoto Protocol 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 files containing spreadsheets (JNGI: Japan's National GHG Inventory 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 exterior 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 0th draft) prepared by the GIO (exterior QC). The companies not only check the input data and the calculation formulas in the files, but also verify the estimations by re-calculating the total amounts of GHG emissions 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 0th 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 guarantee 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.

1.4. Brief General Description of Methodologies and Data Sources Used

The methodology used in estimation of GHG emissions or removals is basically in accordance with the *Revised 1996 IPCC Guidelines*, the *GPG (2000)* and the *GPG-LULUCF*. The country-specific methodologies are also used for some categories (e.g., “4.C. methane emissions from rice cultivation”) in order to 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 *Revised 1996 IPCC Guidelines*, the *GPG (2000)* and the *GPG-LULUCF* 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”)), and where the possibility of emission from a given source is uncertain (e.g., “4.D.3. Indirect emissions from soil in agricultural land”).

1.5. Brief Description of Key Categories

Key category analysis is carried out in accordance with the *GPG (2000)* and the *GPG-LULUCF* (Tier 1, Tier 2 level assessment and trend assessment, qualitative analysis).

1.5.1. GHG Inventory

In FY2012, 38 sources and sinks were identified as Japan’s key categories (Table 1-2). For the base year of the UNFCCC (FY1990), 35 sources and sinks were identified as key categories (Table 1-3). More detailed information is described in Annex 1.

Table 1-2 Japan's key categories in FY2012

	A IPCC Category		B Direct GHGs	L1	T1	L2	T2
#1	1A Stationary Combustion	Solid Fuels	CO2	#1	#3	#4	#11
#2	1A Stationary Combustion	Liquid Fuels	CO2	#2	#1	#9	#8
#3	1A Stationary Combustion	Gaseous Fuels	CO2	#3	#2		
#4	1A3 Mobile Combustion	b. Road Transportation	CO2	#4	#9	#6	
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	#5	#12	#3	#24
#6	2A Mineral Product	1. Cement Production	CO2	#6	#5	#10	#7
#7	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	#7	#4	#1	#1
#8	1A Stationary Combustion	Other Fuels	CO2	#8	#13	#7	#14
#9	6C Waste Incineration		CO2	#9		#5	#22
#10	1A3 Mobile Combustion	d. Navigation	CO2	#10	#14		
#11	1A3 Mobile Combustion	a. Civil Aviation	CO2	#11			
#12	2A Mineral Product	3. Limestone and Dolomite Use	CO2		#17	#18	#27
#13	4A Enteric Fermentation		CH4			#24	
#14	2A Mineral Product	2. Lime Production	CO2			#21	
#15	4C Rice Cultivation		CH4			#17	#26
#16	1A Stationary Combustion		N2O			#16	#23
#17	4B Manure Management		N2O			#11	
#18	4D Agricultural Soils	1. Direct Soil Emissions	N2O			#8	#12
#19	6A Solid Waste Disposal on Land		CH4		#10	#19	#6
#20	4D Agricultural Soils	3. Indirect Emissions	N2O			#12	#15
#21	4B Manure Management		CH4			#15	#19
#22	1A3 Mobile Combustion	b. Road Transportation	N2O			#14	#10
#23	6C Waste Incineration		N2O			#13	
#24	5E Settlements	2. Land converted to Settlements	CO2		#11		#9
#25	6B Wastewater Handling		CH4				#25
#26	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	PFCs			#23	
#27	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs		#18		#13
#28	6B Wastewater Handling		N2O			#22	
#29	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6		#7		#2
#30	5A Forest Land	2. Land converted to Forest Land	CO2				#20
#31	5F Other Land	2. Land converted to Other Land	CO2				#18
#32	5B Cropland	2. Land converted to Cropland	CO2		#19		#21
#33	2B Chemical Industry	3. Adipic Acid	N2O		#8		#16
#34	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6		#15		#3
#35	1A3 Mobile Combustion	a. Civil Aviation	N2O			#2	#5
#36	1A3 Mobile Combustion	d. Navigation	N2O			#20	
#37	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4		#16		#4
#38	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs		#6		#17

N.B. Figures recorded in the Level and Trend columns indicate the ranking of individual level and trend assessments.

Table 1-3 Japan's key categories in FY1990

	A IPCC Category		B Direct GHGs	L1	L2
#1	1A Stationary Combustion	Liquid Fuels	CO2	#1	#7
#2	1A Stationary Combustion	Solid Fuels	CO2	#2	#4
#3	1A3 Mobile Combustion	b. Road Transportation	CO2	#3	#6
#4	1A Stationary Combustion	Gaseous Fuels	CO2	#4	
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	#5	#1
#6	2A Mineral Product	1. Cement Production	CO2	#6	#9
#7	1A3 Mobile Combustion	d. Navigation	CO2	#7	
#8	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	#8	
#9	6C Waste Incineration		CO2	#9	#3
#10	2A Mineral Product	3. Limestone and Dolomite Use	CO2	#10	#22
#11	1A Stationary Combustion	Other Fuels	CO2	#11	#15
#12	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	#12	#5
#13	6A Solid Waste Disposal on Land		CH4	#13	#13
#14	4A Enteric Fermentation		CH4	#14	#27
#15	2B Chemical Industry	3. Adipic Acid	N2O	#15	
#16	1A3 Mobile Combustion	a. Civil Aviation	CO2	#16	
#17	4C Rice Cultivation		CH4	#17	#19
#18	2A Mineral Product	2. Lime Production	CO2		#25
#19	5E Settlements	2. Land converted to Settlements	CO2		#17
#20	4D Agricultural Soils	1. Direct Soil Emissions	N2O		#8
#21	1A3 Mobile Combustion	b. Road Transportation	N2O		#12
#22	4D Agricultural Soils	3. Indirect Emissions	N2O		#14
#23	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs		#21
#24	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6		#10
#25	2B Chemical Industry	1. Ammonia Production	CO2		#28
#26	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4		#11
#27	4B Manure Management		N2O		#18
#28	4B Manure Management		CH4		#16
#29	6B Wastewater Handling		CH4		#24
#30	5A Forest Land	2. Land converted to Forest Land	CO2		#30
#31	5F Other Land	2. Land converted to Other Land	CO2		#29
#32	6C Waste Incineration		N2O		#20
#33	6B Wastewater Handling		N2O		#26
#34	1A3 Mobile Combustion	d. Navigation	N2O		#23
#35	1A3 Mobile Combustion	a. Civil Aviation	N2O		#2

N.B. Figures recorded in the column L (Level) indicate the ranking of level assessments.

1.5.2. KP-LULUCF Activity

As a result of analysis implemented in accordance with *GPG-LULUCF*, Chapter 5, "Afforestation/Reforestation", "Deforestation", "Forest management" and "Revegetation" activities (CO_2) were identified as key categories for Japan's KP-LULUCF activities in FY2012. More detailed information is described in section 11.7 of chapter 11.

1.6. Information on the QA/QC Plan including Verification and Treatment of Confidentiality Issues

The role and the responsibility for each entity in the inventory preparation process are clarified in

Japan's national system. The relevant entities are MOE, GIO, relevant ministries, relevant agencies, relevant organizations, the Committee, selected private consulting companies and the QAWG. The QC activities (e.g., checking estimation accuracy, archiving documents) are carried out in each step of the inventory preparation process in accordance with the *GPG (2000)* and the *GPG-LULUCF* in order to control the inventory's quality.

As a QA activity, the QAWG is established in order to implement a detailed review of each source or sink. The QAWG is composed of experts who are not directly involved in or related to the inventory preparation process. The QAWG reviews several sectors/categories annually with the aim of reviewing the entire inventory within a few years. The QAWG review was implemented for Japan's QA/QC plan in FY2013.

For further information on the national system and process for inventory preparation, see sections 1.2 and 1.3 of this chapter. Detailed information on the QA/QC plan is described in Annex 6.1.

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

1.7.1. GHG Inventory

Total net GHG emissions in Japan for FY2012 were approximately 1,268 million tonnes (CO_2 equivalents). The total net emissions uncertainty was 2% and the uncertainty introduced into the trend in the total emissions was 1%. More detailed information on the uncertainty assessment is described in Annex 7.

Table 1-4 Uncertainty of Japan's GHG inventory

IPCC Category	GHGs	Emissions / Removals [Gg-CO_2 eq.] A	[%]	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions[1)] C	rank
1A. Fuel Combustion (CO_2)	CO_2	1,221,568.1	91.0%	1%	10	0.71%	3
1A. Fuel Combustion (Stationary:CH_4,N_2O)	CH_4, N_2O	5,166.5	0.4%	27%	4	0.11%	8
1A. Fuel Combustion (Transport:CH_4,N_2O)	CH_4, N_2O	2,446.7	0.2%	400%	1	0.77%	2
1B. Fugitive Emissions from Fuels	CO_2, CH_4, N_2O	396.5	0.0%	19%	5	0.01%	9
2. Industrial Processes (CO_2,CH_4,N_2O)	CO_2, CH_4, N_2O	42,246.7	3.1%	7%	8	0.24%	7
2. Industrial Processes (HFCs,PFCs,SF_6)	HFCs, PFCs, SF_6	27,269.0	2.0%	37%	2	0.80%	1
3. Solvent & Other Product Use	N_2O	90.7	0.0%	5%	9	0.00%	10
4. Agriculture	CH_4, N_2O	23,904.8	1.8%	19%	6	0.35%	6
5. LULUCF	CO_2, CH_4, N_2O	-75,065.4	-5.6%	11%	7	0.67%	4
6. Waste	CO_2, CH_4, N_2O	20,028.6	1.5%	32%	3	0.50%	5
Total Net Emissions	(D)	1,268,052.4		(E) [2)] **2%**			

1) C = A × B / D

2) $E = \sqrt{C_1^2 + C_2^2 + \cdots\cdots\cdots}$

1.7.2. KP-LULUCF Activity

Japan's net removals in FY2012 were 53 million tonnes (CO_2 equivalents) and the uncertainty was 12%. More detailed information on the uncertainty assessment is described in section 11.4.1.5 of chapter 11 and Annex 7.

Table 1-5 Uncertainty of Japan's KP-LULUCF activities

Greenhouse gas source and sink activities	GHGs	Emissions/Removals [Gg CO_2eq.]	%	Emissions/Removals Uncertainty [%]	rank	Emissions/Removals Uncertainty as % of toral national emissions [%]	rank
Article 3.3 activities Afforestation and Reforestation	CO_2, N_2O, CH_4	-494	-1%	37%	1	0%	3
Article 3.3 activities Deforestation	CO_2, N_2O, CH_4	1,955	4%	25%	2	-1%	4
Article 3.4 activities Forest management	CO_2, N_2O, CH_4	-53,141	-101%	12%	4	12%	1
Article 3.4 activities Revegetation	CO_2, N_2O, CH_4	-1,162	-2%	17%	3	0%	2
Total		-52,842	-100%	12%			

1.8. General Assessment of the Completeness

In this inventory report, emissions from some categories are not estimated and reported as "NE". In FY2006, GHG emissions and removals from categories that were previously reported as NE were newly estimated by analyzing categories such as those, which possibly result in the emission of considerable amount of GHGs, as well as those, which require substantial improvement in their estimation methodologies.

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 11^{th} 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, as far as we know at this time, 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 verification 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 8 (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. GHGs Emissions and Removals

Total GHGs emissions in FY2012[1,2] (excluding LULUCF[3]) were 1,343 million tonnes (in CO_2 eq.). They increased by 8.8% compared to the emissions in FY1990[4] (excluding LULUCF). Compared to the emissions in the base year under the Kyoto Protocol[5], they increased by 6.5%.

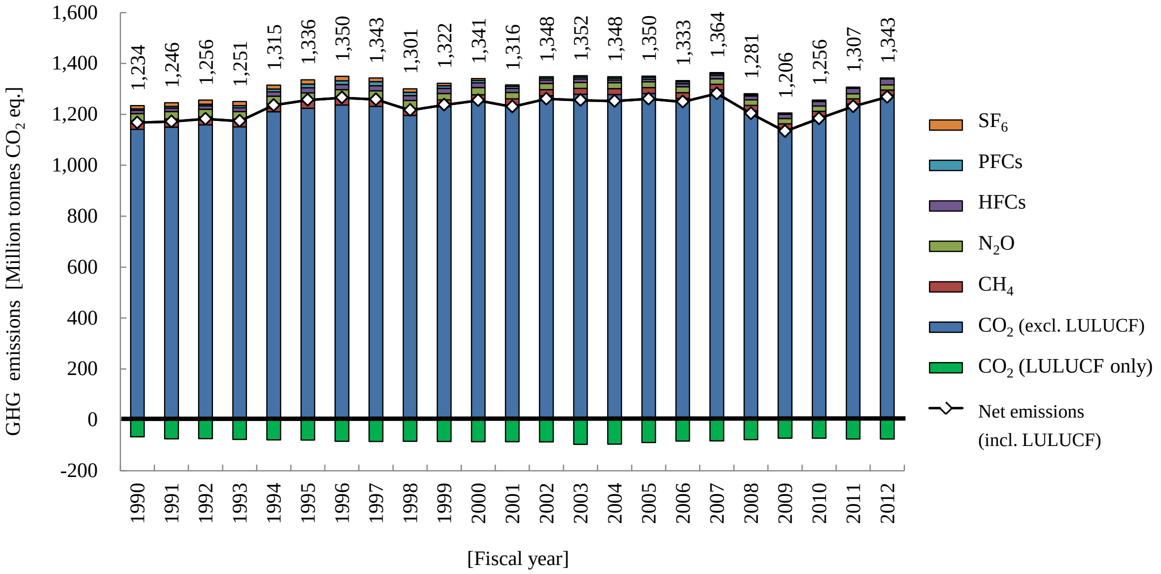

Figure 2-1 Trends in GHG emissions and removals in Japan

Carbon dioxide emissions in FY2012 were 1,276 million tonnes (excluding LULUCF), accounting for 95.0% of total GHGs emissions. They increased by 11.8% since FY1990 and by 2.8% compared to the previous year. Carbon dioxide removals[6] in FY2012 were 75.1 million tonnes, which were equivalent to 5.6% of total GHGs emissions. They increased by 12.2% since FY1990 and decreased by 0.7% compared to the previous year. Methane emissions in FY2012 (excluding LULUCF) were 20.0 million tonnes (in CO_2 eq.), accounting for 1.5% of total GHGs emissions. They decreased by 38.3% since FY1990 and by 1.4% compared to the previous year. Nitrous oxide emissions in FY2012 (excluding

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 and SF_6 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 *Second Assessment Report* (1995) issued by the Intergovernmental Panel on Climate Change (IPCC).

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

4 The sum of CO_2, CH_4 and N_2O emissions converted to CO_2 equivalents multiplied by their respective GWP.

5 Japan's base year under the Kyoto Protocol for CO_2, CH_4, N_2O emissions is FY1990, while CY1995 is the base year for HFCs, PFCs, and SF_6 emissions.

6 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 which can be accounted for compliance under the Kyoto Protocol (for 'forest management', 13 million carbon tonnes as the upper limit for Japan is given in the appendix to the annex to decision 16/CMP.1.)

LULUCF) were 31.9 million tonnes (in CO_2 eq.), accounting for 1.5% of total GHGs emissions. They decreased by 31.9% since FY1990 and by 1.3% compared to the previous year.

Hydrofluorocarbons emissions in CY2012 were 22.9 million tonnes (in CO_2 eq.), accounting for 1.7% of total GHGs emissions. They increased by 82.0% since CY1990 and by 12.1% compared to the previous year. Perfluorocarbons emissions in CY2012 were 2.8 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 47.7% since CY1990 and by 8.6% compared to the previous year. Sulfur hexafluoride emissions in CY2012 were 1.6 million tonnes (in CO_2 eq.), accounting for 0.1% of total GHGs emissions. They decreased by 88.0% since CY1990 and by 3.2% compared to the previous year.

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

[Million tonnes CO_2 eq.]	GWP	KPBY	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2 (excl. LULUCF)	1	1,144.1	1,141.1	1,150.1	1,158.5	1,150.9	1,210.7	1,223.7	1,236.6	1,231.5	1,195.9	1,230.8
CO_2 (incl. LULUCF)	1	NA	1,074.2	1,075.8	1,084.5	1,073.7	1,131.6	1,144.2	1,152.3	1,146.7	1,111.2	1,145.9
CO_2 (LULUCF only)	1	NA	-66.9	-74.3	-74.1	-77.2	-79.0	-79.5	-84.3	-84.8	-84.6	-84.9
CH_4 (excl. LULUCF)	21	33.4	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6
CH_4 (incl. LULUCF)	21	NA	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6
N_2O (excl. LULUCF)	310	32.6	29.7	29.3	29.5	29.3	30.6	31.0	32.1	32.8	31.3	24.9
N_2O (incl. LULUCF)	310	NA	29.8	29.3	29.5	29.4	30.6	31.1	32.1	32.8	31.3	24.9
HFCs	HFC-134a: 1,300 etc.	20.2	12.6	13.7	14.1	14.4	16.8	20.3	19.9	19.9	19.4	19.9
PFCs	PFC-14: 6,500 etc.	14.0	5.3	6.1	6.2	8.9	10.9	14.3	14.8	16.2	13.4	10.4
SF_6	23,900	16.9	13.2	14.7	16.2	16.2	15.4	17.0	17.5	15.0	13.6	9.3
Gross total (excl. LULUCF)		1,261.3	1,234.3	1,245.8	1,256.1	1,250.8	1,314.8	1,335.9	1,349.7	1,343.3	1,300.7	1,321.9
Net total (incl. LULUCF)		NA	1,167.5	1,171.6	1,182.1	1,173.7	1,235.9	1,256.5	1,265.5	1,258.6	1,216.1	1,237.0

[Million tonnes CO_2 eq.]	GWP		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CO_2 (excl. LULUCF)	1		1,251.5	1,236.3	1,273.4	1,278.5	1,277.9	1,282.1	1,263.0	1,296.2	1,213.8	1,141.5
CO_2 (incl. LULUCF)	1		1,165.8	1,150.5	1,186.3	1,182.3	1,182.1	1,192.8	1,179.7	1,213.7	1,136.3	1,068.9
CO_2 (LULUCF only)	1		-85.7	-85.9	-87.1	-96.2	-95.8	-89.4	-83.3	-82.4	-77.5	-72.5
CH_4 (excl. LULUCF)	21		26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1
CH_4 (incl. LULUCF)	21		26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1
N_2O (excl. LULUCF)	310		27.5	24.2	23.5	23.3	23.4	23.0	23.0	21.8	21.7	21.4
N_2O (incl. LULUCF)	310		27.5	24.2	23.6	23.3	23.4	23.0	23.0	21.9	21.7	21.5
HFCs	HFC-134a: 1,300 etc.		18.8	16.2	13.7	13.8	10.6	10.5	11.7	13.3	15.3	16.5
PFCs	PFC-14: 6,500 etc.		9.6	8.0	7.4	7.2	7.5	7.0	7.3	6.4	4.6	3.3
SF_6	23,900		7.2	6.0	5.6	5.3	5.1	4.8	4.9	4.4	3.8	1.9
Gross total (excl. LULUCF)			1,340.5	1,315.7	1,347.8	1,351.7	1,347.6	1,350.3	1,332.5	1,364.3	1,280.9	1,205.7
Net total (incl. LULUCF)			1,254.9	1,229.8	1,260.8	1,255.5	1,251.9	1,261.0	1,249.2	1,281.8	1,203.4	1,133.2

[Million tonnes CO_2 eq.]	GWP		2010	2011	2012	Changes in emissions/removals (2012)		
						KPBY	1990	Previous year
CO_2 (excl. LULUCF)	1		1,191.1	1,240.6	1,275.6	11.5%	11.8%	2.8%
CO_2 (incl. LULUCF)	1		1,118.7	1,165.0	1,200.5	-	11.8%	3.0%
CO_2 (LULUCF only)	1		-72.4	-75.6	-75.1	-	12.2%	-0.7%
CH_4 (excl. LULUCF)	21		20.7	20.3	20.0	-40.1%	-38.3%	-1.4%
CH_4 (incl. LULUCF)	21		20.7	20.3	20.0	-	-38.3%	-1.4%
N_2O (excl. LULUCF)	310		20.8	20.5	20.2	-38.0%	-31.9%	-1.3%
N_2O (incl. LULUCF)	310		20.8	20.5	20.2	-	-32.1%	-1.3%
HFCs	HFC-134a: 1,300 etc.		18.3	20.5	22.9	13.4%	82.0%	12.1%
PFCs	PFC-14: 6,500 etc.		3.4	3.0	2.8	-80.4%	-47.7%	-8.6%
SF_6	23,900		1.9	1.6	1.6	-90.6%	-88.0%	-3.2%
Gross total (excl. LULUCF)			1,256.1	1,306.5	1,343.1	6.5%	8.8%	2.8%
Net total (incl. LULUCF)			1,183.7	1,230.9	1,268.1	-	8.6%	3.0%

* KPBY: Base year of Kyoto Protocol
* NA: Not applicable
* NE: Not estimated
* LULUCF: Land Use, Land-Use Change and Forestry
* CH_4 and N_2O emissions in Table 1 include emissions from LULUCF based on the estimation method decided by the UNFCCC. On the contrary, since emissions from LULUCF are regarded as RMU (removal unit) according to Article 3.3 of the Kyoto Protocol, they are not included in GHGs emissions based on Kyoto Protocol (refer annex 8 table 1).

2.1.2. CO_2 Emissions per Capita

Total CO_2 emissions in FY2012 (excluding LULUCF) were 1,276 million tonnes, and on a per capita basis, they were 10.00 tonnes. Compared to FY1990, they increased by 11.8% in total emissions, and by 8.4% in per capita emissions. Compared to the previous year, they increased by 2.8% in total emissions, and by 3.0% in per capita emissions.

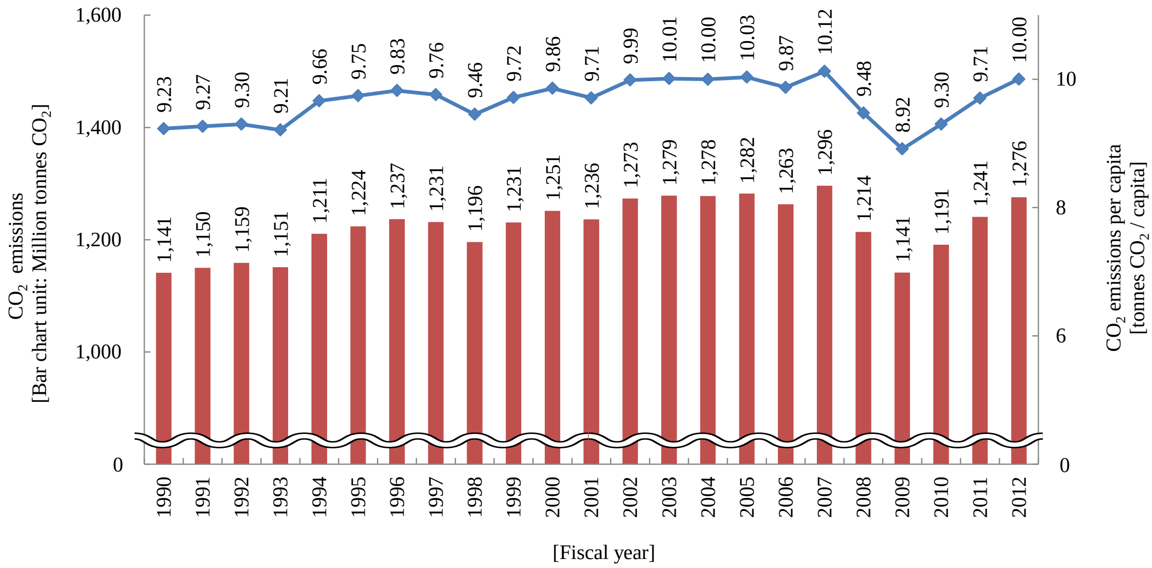

Figure 2-2 Trends in total CO_2 emissions and CO_2 emissions per capita

Source of population data: Ministry of Public Management, Home Affairs, Posts and Telecommunications Japan, *Population Census* and *Annual Report on Current Population Estimates*

2.1.3. CO_2 Emissions per Unit of GDP

Carbon dioxide emissions per unit of GDP (million yen) in FY2012 were 2.46 tonnes. They decreased by 7.1% since FY1990 and increased by 2.1% compared to the previous year.

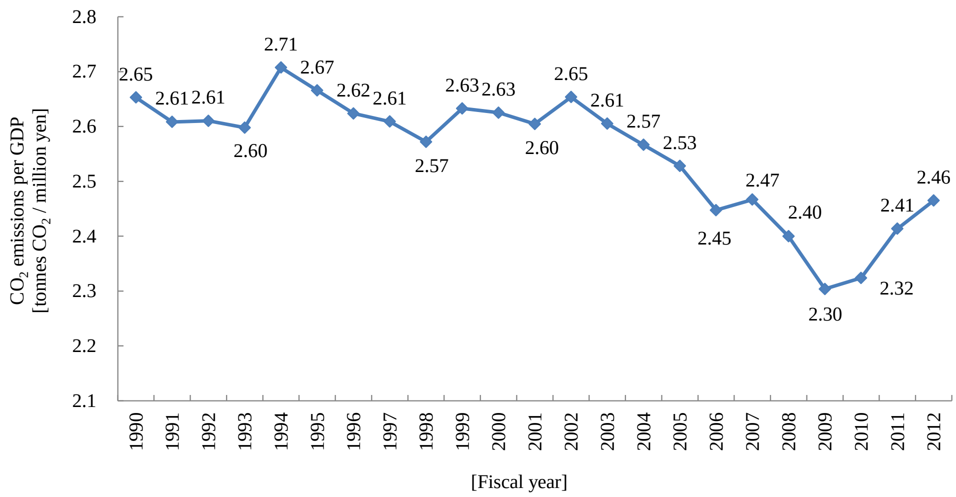

Figure 2-3 Trends in CO_2 emissions per unit of GDP

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

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

2.2.1. CO_2

Carbon dioxide emissions in FY2012 were 1,276 million tonnes (excluding LULUCF), accounting for 95.0% of total GHGs emissions. They increased by 11.8% since FY1990 and by 2.8% compared to the previous year.

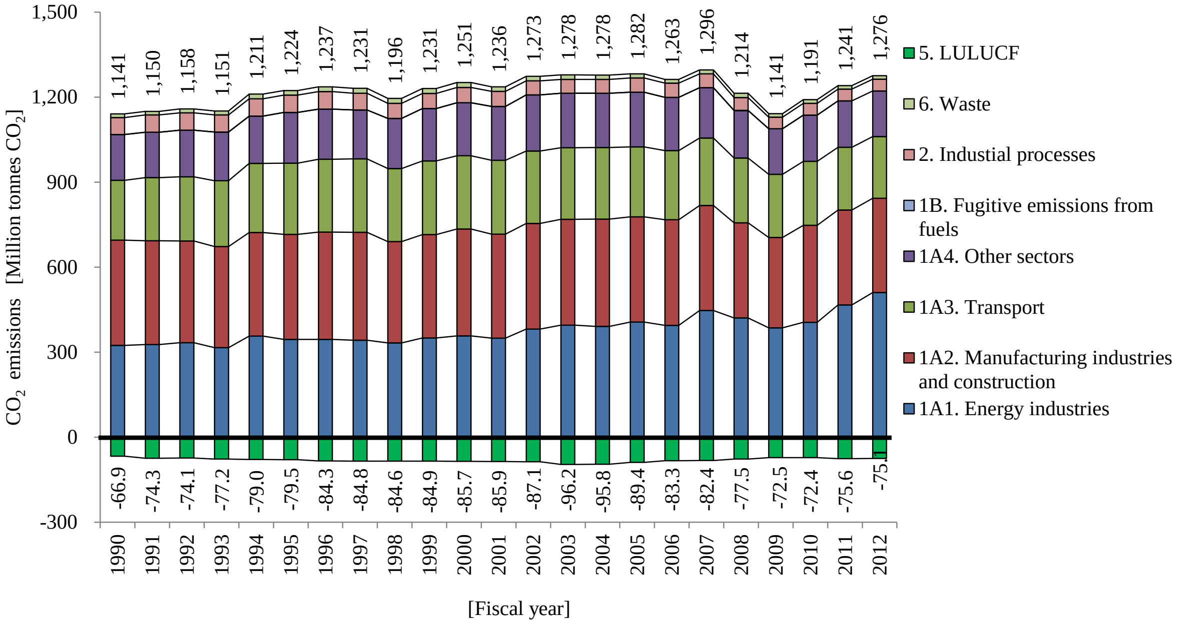

Figure 2-4 Trends in CO_2 emissions

The breakdown of CO_2 emissions in FY2012 shows that fuel combustion accounts for 95.8%, and is followed by industrial processes (3.3%) and waste sectors (1.0%). As for the breakdown of CO_2 emissions within the fuel combustion category, energy industries accounts for 40.0% and is followed by manufacturing industries and construction at 26.1%, transport at 17.0%, and other sectors[7] at 12.6%. The main driving factor for the increase in CO_2 emissions compared to the previous year is the increased fossil fuel consumption in response to the expansion of thermal power generation since the Great East Japan Earthquake.

By looking at the changes in emissions by sector, emissions from fuel combustion in the energy industries increased by 57.4% since FY1990 and by 9.3% compared to the previous year. The main driving factor for the increase compared to the emissions in FY1990 is increase in electricity consumption. Emissions from manufacturing industries and construction decreased by 10.3% since FY1990 and by 0.5% compared to the previous year. Emissions from transport increased by 3.0% compared to FY1990 and decreased by 1.9% compared to the previous year. The main driving factor for the increase compared to the emissions in FY1990 is increase in demand for passenger transportation, compensating decrease in volume of freight transportation. Emissions from other sectors decreased by 0.5% since FY1990 and decreased by 1.6% compared to the previous year.

Carbon dioxide removals in FY2012 were 75.1 million tonnes, which were equivalent to 5.6% of total GHGs emissions. They increased by 12.2% since FY1990 and decreased by 0.7% compared to the

[7] It covers emissions from commercial/institutional, residential and agriculture/forestry/fisheries.

previous year.

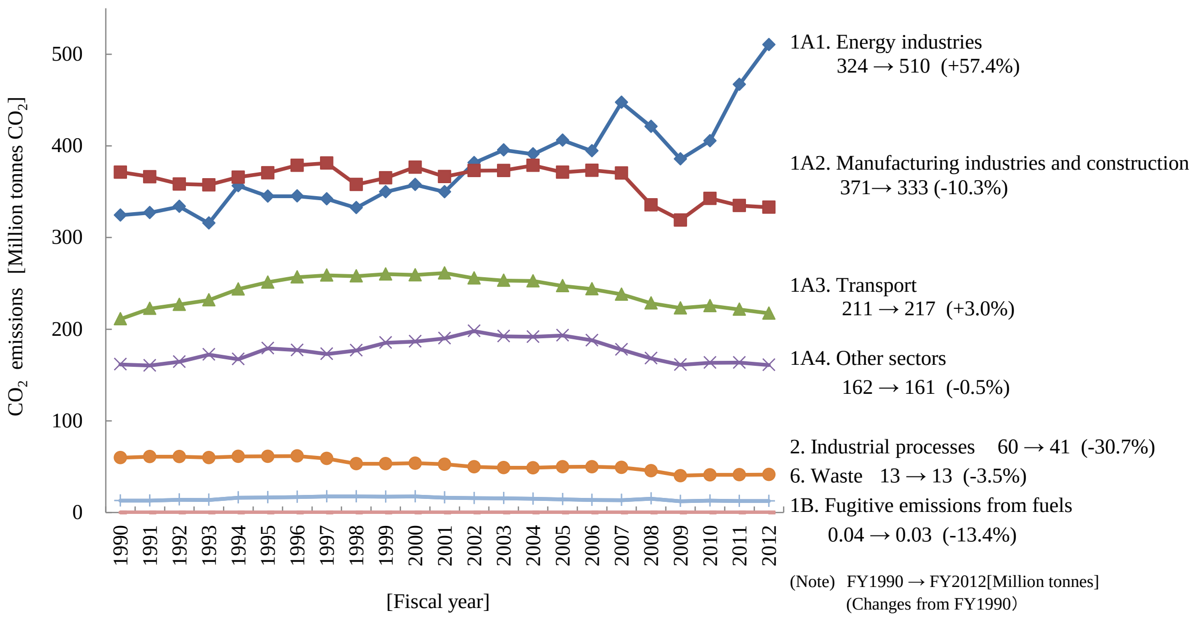

Figure 2-5 Trends in CO_2 emissions in each sector

(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	2008	2009	2010	2011	2012
1A. Fuel combustion	1,068,260	1,145,769	1,180,044	1,217,697	1,153,045	1,088,802	1,136,981	1,186,937	1,221,568
1A1. Energy industries	324,253	344,948	357,574	406,039	420,888	385,493	405,372	466,935	510,263
Public electricity and heat production	297,074	315,399	330,863	378,921	395,340	356,702	379,340	439,704	485,184
Petroleum refining	15,893	16,956	17,285	16,441	14,324	14,564	15,038	14,064	13,745
Manufacture of solid fuels and other energy industries	11,286	12,592	9,426	10,677	11,225	14,227	10,994	13,167	11,334
1A2. Manufacturing industries and construction	371,311	370,539	376,778	371,229	335,621	319,093	342,657	334,883	333,095
Iron and steel	149,600	141,862	150,776	152,741	143,269	134,610	151,892	147,767	149,983
Non-ferrous metals	6,092	4,770	3,042	2,634	2,333	2,120	2,075	1,974	1,889
Chemicals	64,736	74,806	67,216	58,650	53,325	52,549	53,588	52,420	50,096
Pulp, paper and print	25,825	29,449	29,035	26,553	22,845	21,242	20,329	20,805	20,950
Food processing, beverages and tobacco	13,129	14,407	13,161	11,326	8,862	8,826	8,974	8,538	8,236
Other	111,929	105,245	113,547	119,326	104,987	99,746	105,800	103,378	101,941
1A3. Transport	211,057	251,177	259,138	247,212	228,349	223,043	225,508	221,559	217,309
Civil aviation	7,162	10,278	10,677	10,799	10,277	9,781	9,193	9,001	9,524
Road transportation	189,228	225,389	232,885	222,851	206,180	202,289	205,025	201,417	196,380
Railways	935	822	711	647	604	590	574	555	554
Navigation	13,731	14,687	14,865	12,915	11,288	10,383	10,716	10,586	10,850
1A4. Other sectors	161,638	179,105	186,554	193,217	168,186	161,173	163,445	163,560	160,902
Commercial/institutional	83,590	93,259	101,388	110,476	98,506	92,932	91,877	94,093	91,426
Residential	56,668	66,320	68,958	67,583	59,023	57,792	61,074	58,941	58,324
Agriculture/forestry/fisheries	21,380	19,526	16,207	15,158	10,657	10,449	10,495	10,526	11,152
1B. Fugitive emissions from fuels	37	51	36	38	38	35	33	33	32
2. Industrial processes	59,876	61,333	53,887	49,903	45,613	40,189	41,074	41,182	41,496
Mineral products	55,311	56,756	49,746	46,774	42,883	37,589	38,177	38,391	38,906
Chemical industry	4,209	4,220	3,893	2,887	2,574	2,488	2,737	2,629	2,416
Metal production	356	357	248	242	156	112	160	162	174
5. LULUCF	-66,898	-79,470	-85,687	-89,354	-77,533	-72,524	-72,368	-75,599	-75,072
6. Waste	12,966	16,534	17,494	14,491	15,136	12,436	12,979	12,480	12,515
Total (including LULUCF)	1,074,239	1,144,218	1,165,774	1,192,774	1,136,299	1,068,939	1,118,699	1,165,033	1,200,539
Total (excluding LULUCF)	1,141,138	1,223,687	1,251,461	1,282,128	1,213,832	1,141,463	1,191,067	1,240,632	1,275,611

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

2.2.2. CH_4

Methane emissions in FY2012 were 20.0 million tonnes (in CO_2 eq., including LULUCF), accounting for 1.5% of total GHGs emissions. They decreased by 38.3% since FY1990 and by 1.4% compared to the previous year. Their decrease since FY1990 is mainly a result of a 55% decrease in emissions from the waste sector (solid waste disposal on land).

Breakdown of the FY2012 emissions shows that the largest source is enteric fermentation accounting for 32%. It is followed by rice cultivation (27%) and solid waste disposal on land (15%).

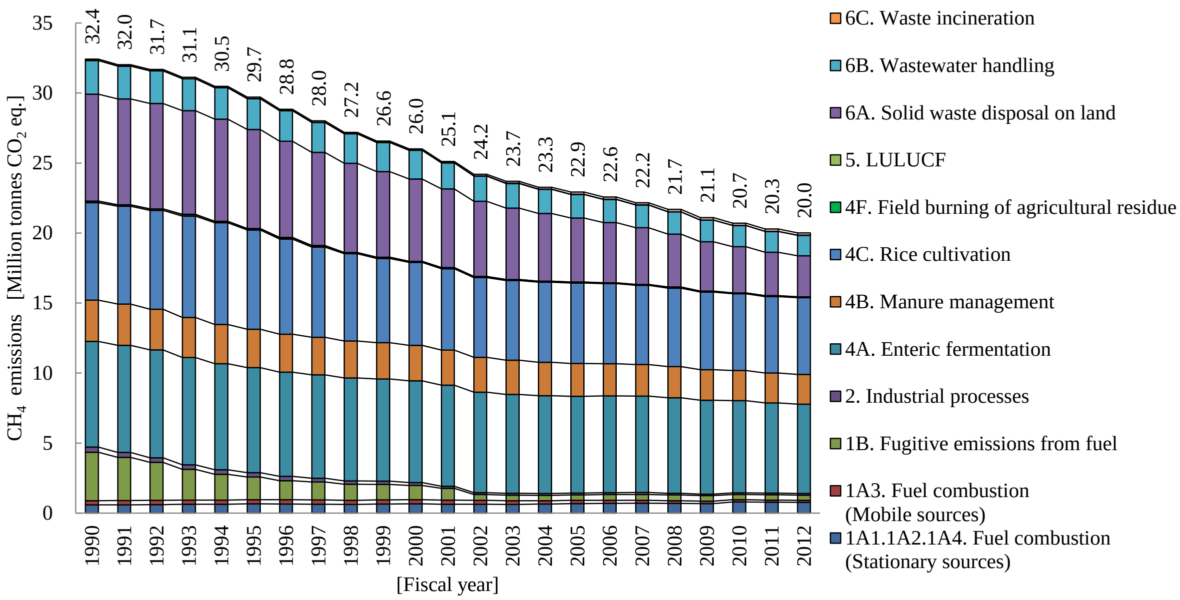

Figure 2-6 Trends in CH_4 emissions

Table 2-3 Trends in CH_4 emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
1A. Fuel combustion	887	964	957	911	887	861	957	936	920
1A1. Energy industries	30	34	43	31	31	30	42	69	78
1A2. Manufacturing industries and construction	355	364	354	387	438	436	516	512	497
1A3. Transport	295	306	297	235	188	176	166	158	155
1A4. Other sectors	207	259	263	258	230	219	233	198	190
1B. Fugitive emissions from fuels	3,466	1,609	1,023	387	408	394	376	374	365
1B1. Solid fuels	3,236	1,344	749	65	46	46	44	45	47
1B2. Oil & Natural gas	231	265	274	322	362	348	331	330	317
2. Industrial processes	357	321	195	133	121	109	118	120	120
4. Agriculture	17,559	17,418	15,801	15,064	14,712	14,480	14,272	14,091	14,037
4A. Enteric fermentation	7,550	7,489	7,265	6,912	6,829	6,691	6,577	6,441	6,379
4B. Manure management	2,949	2,752	2,538	2,347	2,223	2,185	2,162	2,134	2,121
4C. Rice cultivation	6,960	7,083	5,920	5,739	5,599	5,545	5,477	5,460	5,480
4F. Field burning of agricultural residue	101	94	77	65	62	58	56	56	57
5. LULUCF	9	9	8	9	22	9	4	5	2
6. Waste	10,145	9,381	8,023	6,422	5,546	5,256	4,972	4,766	4,565
6A. Solid waste disposal on land	7,637	7,070	5,875	4,568	3,767	3,525	3,292	3,096	2,928
6B. Wastewater handling	2,402	2,207	2,043	1,685	1,592	1,545	1,517	1,491	1,464
6C. Waste incineration	13	15	13	14	12	10	10	10	8
6D. Other (Waste)	92	89	91	155	175	176	153	169	165
Total (including LULUCF)	32,423	29,702	26,007	22,927	21,696	21,109	20,699	20,292	20,008
Total (excluding LULUCF)	32,415	29,693	25,999	22,917	21,674	21,100	20,695	20,287	20,007

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

2.2.3. N_2O

Nitrous oxide emissions in FY2012 were 20.2 million tonnes (in CO_2 eq., including LULUCF), accounting for 1.5% of total GHGs emissions. They decreased by 32.1% since FY1990 and by 1.3% compared to the previous year. Their decrease since FY1990 is mainly a result of a 92.4% decrease in emissions from industrial processes (e.g. adipic acid production). There is a sharp decline in emissions from the industrial processes 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 FY2012 emissions shows that the largest source is agricultural soils accounting for 30%. It is followed by fuel combustion (stationary sources) (22%) and manure management (18%).

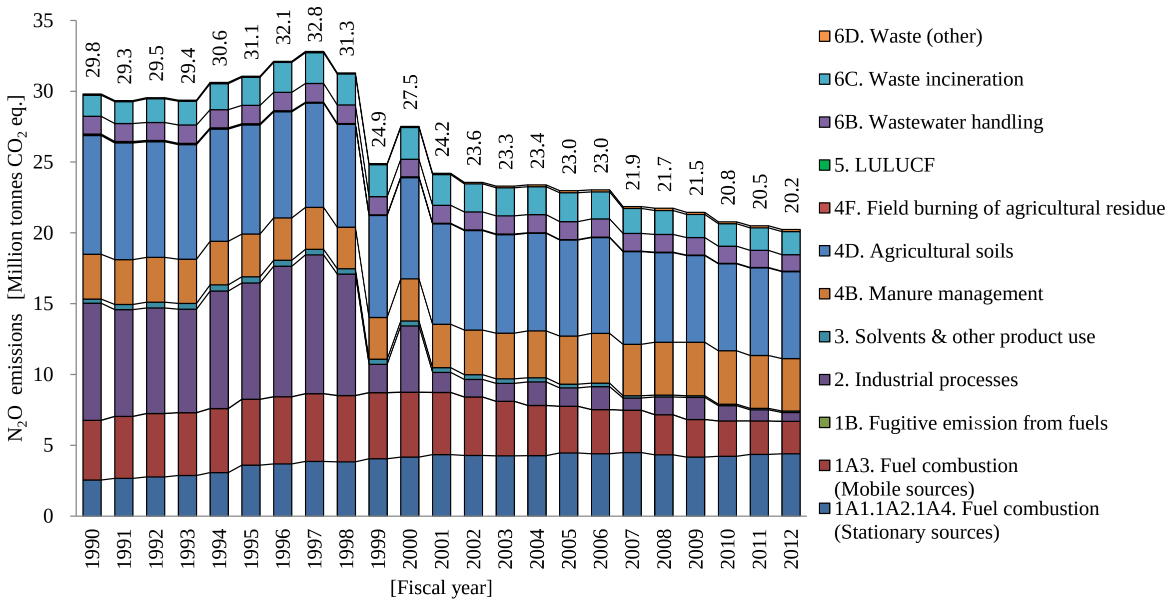

Figure 2-7 Trends in N_2O emissions

Table 2-4 Trends in N_2O emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
1A. Fuel combustion	6,768	8,249	8,742	7,749	7,155	6,816	6,721	6,726	6,693
1A1. Energy industries	922	1,413	1,700	2,068	2,022	1,934	1,916	2,064	2,065
1A2. Manufacturing industries and construction	1,354	1,829	2,116	2,036	1,988	1,917	1,988	1,967	1,989
1A3. Transport	4,218	4,655	4,570	3,294	2,822	2,653	2,492	2,367	2,292
1A4. Other sectors	273	352	356	351	322	312	325	329	347
1B. Fugitive emissions from fuels	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2. Industrial processes	8,267	8,213	4,690	1,300	1,262	1,559	1,078	788	631
3. Solvent & Other product use	287	438	341	266	129	120	99	97	91
4. Agriculture	11,576	10,748	10,151	10,200	10,075	9,925	9,938	9,935	9,868
4B. Manure management	3,171	3,021	2,983	3,402	3,734	3,776	3,779	3,734	3,712
4D. Agricultural soils	8,377	7,702	7,147	6,780	6,324	6,133	6,144	6,185	6,140
4F. Field burning of agricultural residue	27	26	22	18	17	16	16	16	16
5. LULUCF	71	50	30	14	11	8	6	5	4
6. Waste	2,830	3,367	3,566	3,443	3,101	3,025	2,934	2,948	2,949
6B. Wastewater handling	1,256	1,307	1,244	1,263	1,253	1,236	1,221	1,213	1,175
6C. Waste incineration	1,493	1,981	2,242	2,042	1,694	1,633	1,577	1,585	1,628
6D. Waste (other)	81	79	81	138	155	156	136	150	146
Total (including LULUCF)	29,799	31,065	27,521	22,973	21,733	21,454	20,776	20,499	20,235
Total (excluding LULUCF)	29,728	31,015	27,491	22,959	21,722	21,446	20,770	20,494	20,231

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

2.2.4. HFCs

Hydrofluorocarbons emissions in CY2012[8] were 22.9 million tonnes (in CO_2 eq.), accounting for 1.7% of total GHGs emissions. They increased by 82.0% since CY1990, and by 12.1% compared to the previous year. Their increase since CY1990 is mainly a result of an increase in emissions from refrigerants (+21.9 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 CY2012 emissions shows that the largest source is refrigerants of refrigeration and air conditioning equipment accounting for 96%. It is followed by aerosols/ metered dose inhalers (MDI) (2%).

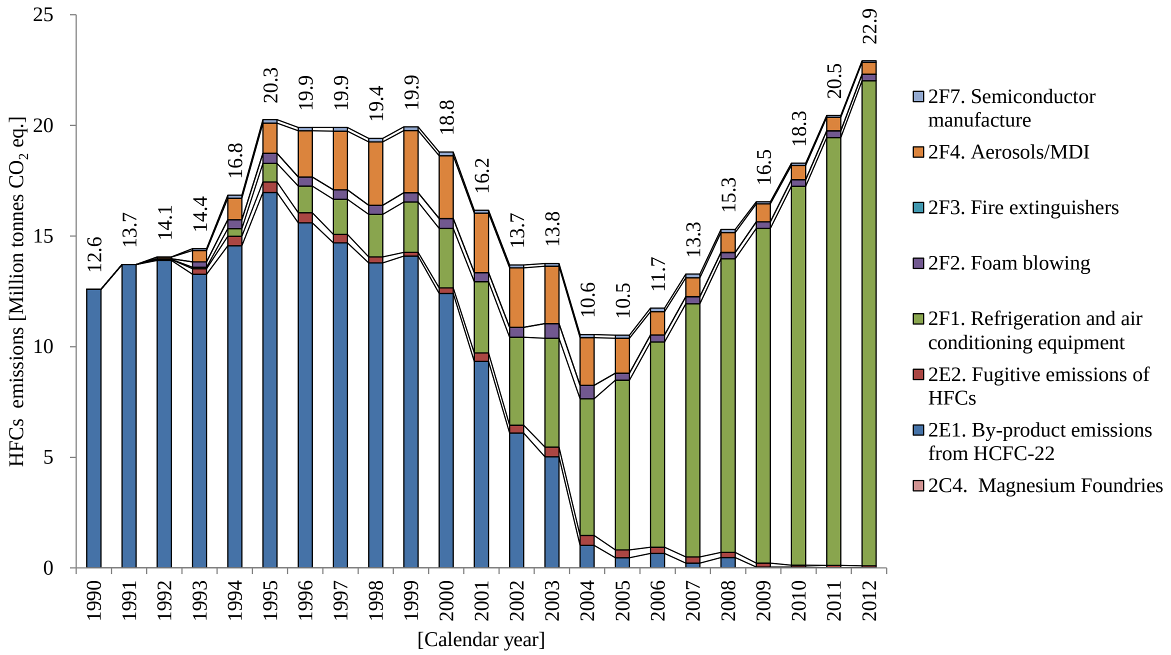

Figure 2-8 Trends in HFCs emissions

Table 2-5 Trends in HFCs emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
2C4. Magnesium Foundries	NO	NO	NO	NO	NO	NO	NO	1	1
2E. Production of F-gas	12,594	17,445	12,660	816	702	222	128	113	92
2E1. By-product emissions from production of HCFC-22	12,592	16,965	12,402	463	469	40	42	13	14
2E2. Fugitive emissions of HFCs	1	480	258	353	233	182	86	100	78
2F. Consumption of F-gases	2	2,815	6,141	9,702	14,597	16,324	18,163	20,338	22,832
2F1. Refrigeration and air conditioning equipment	NO	840	2,689	7,667	13,269	15,126	17,123	19,339	21,920
2F2. Foam blowing	1	452	440	316	286	290	291	295	294
2F3. Fire extinguishers	NO	NO	4	6	6	7	7	7	7
2F4. Aerosols/MDI	NO	1,365	2,834	1,572	890	809	640	609	534
2F7. Semiconductor manufacture	0.4	158	174	141	146	92	102	89	76
Total	12,595	20,260	18,800	10,518	15,299	16,547	18,291	20,452	22,926

8 Emissions of HFCs, PFCs and SF_6 are estimated on a calendar year (CY) basis.

2.2.5. PFCs

Perfluorocarbons emissions in CY2012 were 2.8 million tonnes (in CO_2 eq.), accounting for 0.2% of total GHGs emissions. They decreased by 47.7% since CY1990, and by 8.6% compared to the previous year. Their decrease since CY1990 (-66.0%) is mainly a result of a decrease in emissions from the solvents.

Breakdown of the CY2012 emissions shows that the largest source is semiconductor for manufacture accounting for 49%. It is followed by solvents such as the ones for washing metals (46%) and fugitive emissions of PFCs (4%).

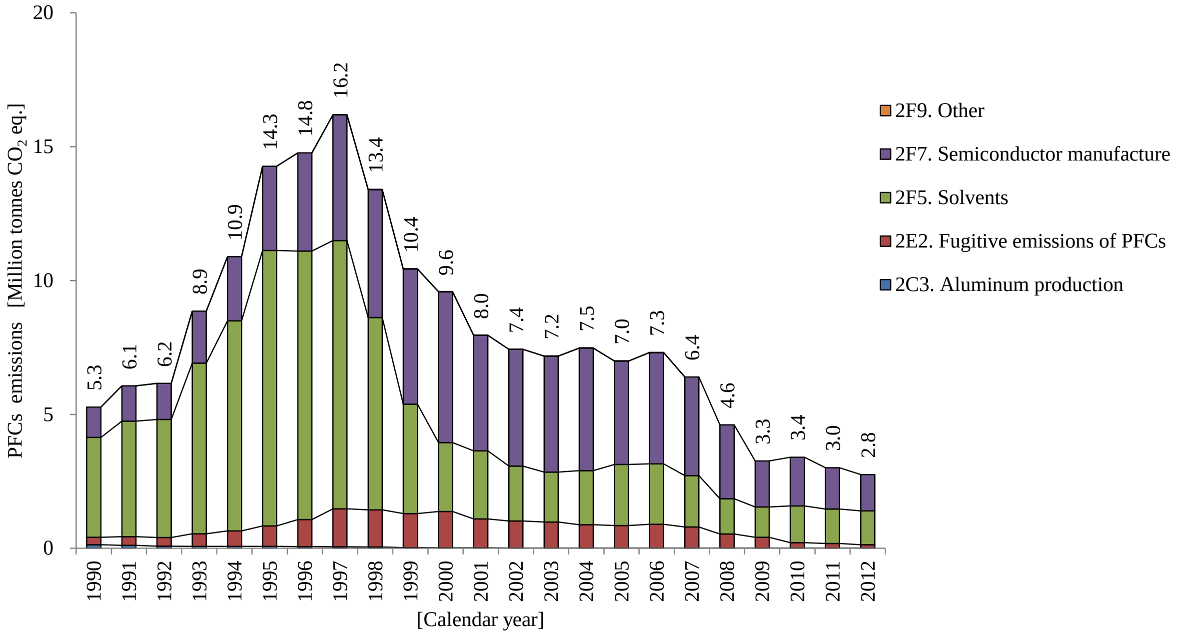

Figure 2-9 Trends in PFCs emissions

Table 2-6 Trends in PFCs emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
2C3. Aluminum production	137	70	18	15	15	11	10	10	9
2E2. Fugitive emissions of PFCs	276	763	1,359	837	524	399	200	172	122
2F. Consumption of F-gases	4,863	13,439	8,207	6,138	4,077	2,855	3,198	2,834	2,627
2F5. Solvents	3,726	10,294	2,569	2,278	1,318	1,137	1,376	1,284	1,266
2F7. Semiconductor manufacture	1,138	3,144	5,637	3,861	2,756	1,715	1,819	1,545	1,361
2F9. Other	NO	NO	NO	0.2	2	2	3	5	NO
Total	5,277	14,271	9,583	6,991	4,615	3,265	3,409	3,016	2,758

2.2.6. SF_6

Sulfur hexafluoride emissions in CY2012 were 1.6 million tonnes (in CO_2 eq.), accounting for 0.1% of total GHGs emissions. They decreased by 88.0% since CY1990, and by 3.2% compared to the previous year. Their decrease since CY1990 (-91.1%) 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.

Breakdown of the CY2012 emissions shows that the largest source is electrical equipment accounting for 48%. It is followed by semiconductor manufacture (32%) and aluminum and magnesium foundries (12%).

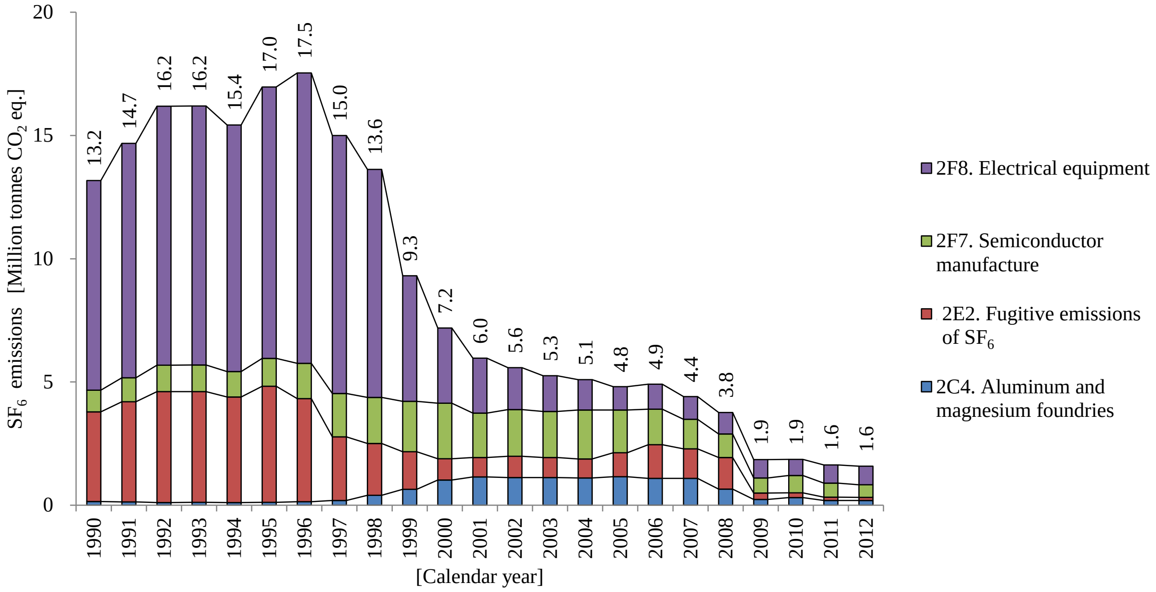

Figure 2-10 Trends in SF_6 emissions

Table 2-7 Trends in SF_6 emissions

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
2C4. SF_6 used in aluminum and magnesium foundries	154	120	1,028	1,157	652	239	308	191	191
2E2. Fugitive emissions of SF_6	3,638	4,708	860	975	1,288	261	198	139	129
2F. Consumption of F-gases	9,376	12,134	5,300	2,676	1,821	1,352	1,356	1,308	1,265
2F7. Semiconductor manufacture	872	1,129	2,250	1,733	952	606	704	567	511
2F8. Electrical equipment	8,504	11,005	3,050	943	868	745	652	741	754
Total	13,168	16,961	7,188	4,808	3,761	1,851	1,862	1,638	1,585

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

The breakdown of GHGs emissions and removals in FY2012 by sector[9] shows that energy accounts for 91.5% of total GHGs emissions. It is followed by industrial processes (5.2%), agriculture (1.9%), waste (1.8%) and solvents and other product use (0.01%).

Removals by LULUCF in FY2012 were equivalent to 5.6% of total GHGs emissions.

[9] It implies "Category" indicated in the *Revised 1996 IPCC Guidelines* and CRF.

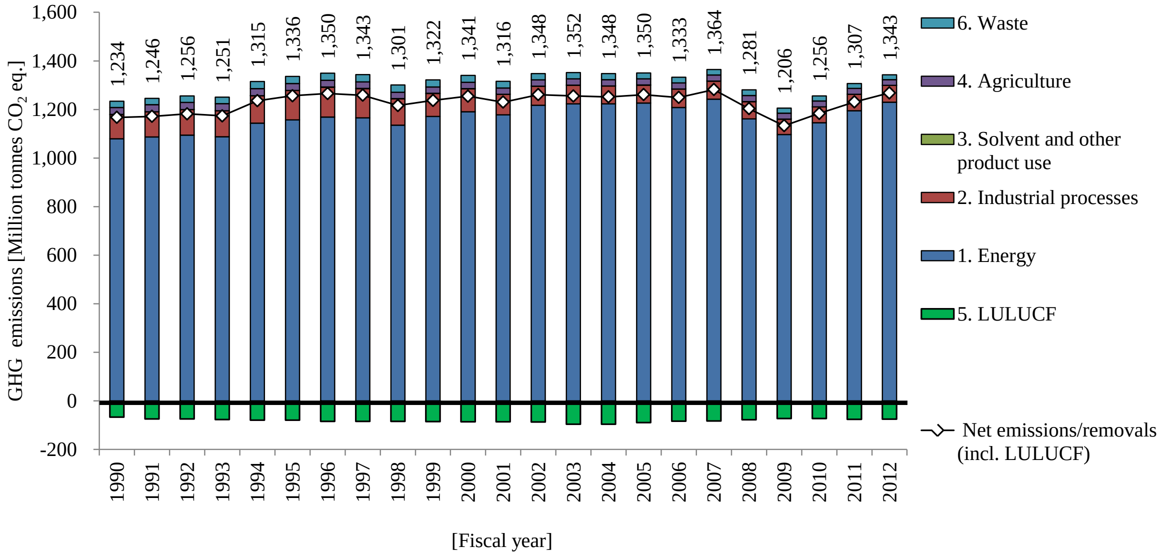

Figure 2-11 Trends in GHG emissions and removals in each sector

Table 2-8 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	1,079.4	1,087.1	1,094.4	1,087.6	1,143.6	1,156.6	1,168.7	1,165.8	1,135.6	1,170.9
2. Industrial processes	99.5	103.3	105.2	107.0	113.0	121.4	123.4	120.1	108.6	95.2
3. Solvent and other product use	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
4. Agriculture	29.1	29.1	29.1	29.1	28.7	28.2	27.5	26.9	26.5	26.2
5. LULUCF	-66.8	-74.2	-74.0	-77.1	-78.9	-79.4	-84.2	-84.7	-84.6	-84.9
6. Waste	25.9	25.9	27.0	26.6	29.1	29.3	29.6	30.0	29.7	29.2
Net emissions/removals (incl. LULUCF)	1,167.5	1,171.6	1,182.1	1,173.7	1,235.9	1,256.5	1,265.5	1,258.6	1,216.1	1,237.0
Emissions (excl. LULUCF)	1,234.3	1,245.8	1,256.1	1,250.8	1,314.8	1,335.9	1,349.7	1,343.3	1,300.7	1,321.9

[Million tonnes CO_2 eq.]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1. Energy	1,190.8	1,177.9	1,217.7	1,223.3	1,223.1	1,226.8	1,208.2	1,242.2	1,161.5	1,096.9
2. Industrial processes	94.3	84.3	77.9	76.6	73.8	73.7	75.7	74.3	70.7	63.5
3. Solvent and other product use	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.1	0.1
4. Agriculture	26.0	25.8	25.6	25.5	25.4	25.3	25.3	25.1	24.8	24.4
5. LULUCF	-85.6	-85.8	-87.0	-96.2	-95.8	-89.3	-83.3	-82.4	-77.5	-72.5
6. Waste	29.1	27.3	26.3	26.0	25.1	24.4	23.1	22.5	23.8	20.7
Net emissions/removals (incl. LULUCF)	1,254.9	1,229.8	1,260.8	1,255.5	1,251.9	1,261.0	1,249.2	1,281.8	1,203.4	1,133.2
Emissions (excl. LULUCF)	1,340.5	1,315.7	1,347.8	1,351.7	1,347.6	1,350.3	1,332.5	1,364.3	1,280.9	1,205.7

[Million tonnes CO_2 eq.]	2010	2011	2012
1. Energy	1,145.1	1,195.0	1,229.6
2. Industrial processes	65.8	67.2	69.5
3. Solvent and other product use	0.1	0.1	0.1
4. Agriculture	24.2	24.0	23.9
5. LULUCF	-72.4	-75.6	-75.1
6. Waste	20.9	20.2	20.0
Net emissions/removals (incl. LULUCF)	1,183.7	1,230.9	1,268.1
Emissions (excl. LULUCF)	1,256.1	1,306.5	1,343.1

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

2.3.1. Energy

Emissions from the energy sector in FY2012 were 1,230 million tonnes (in CO_2 equivalents). They increased by 13.9% since FY1990 and by 2.9% compared to the previous year.

Breakdown of the FY2012 emissions shows that CO_2 from fuel combustion accounts for 99.3%. The largest source within the fuel combustion is liquid fuel CO_2, which accounted for 43%, and is then followed by solid fuel CO_2 (35%) and gaseous fuel CO_2 (21%).

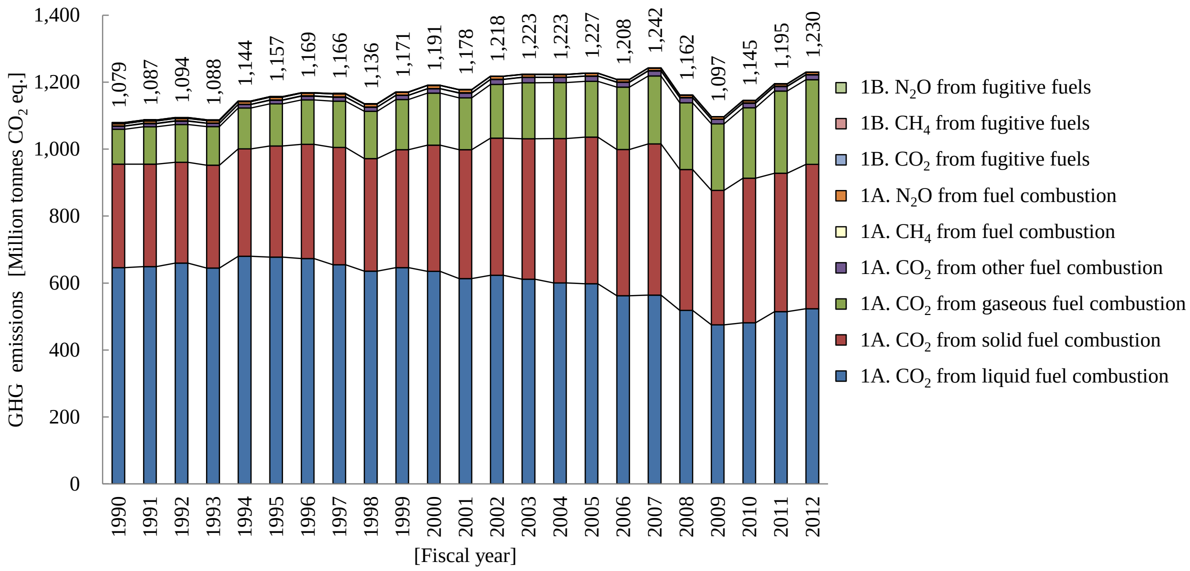

Figure 2-12 Trends in GHG emissions from the energy sector

Table 2-9 Trends in GHG emissions from the energy sector

[Thousand tonnes CO_2 eq.]

Source category	1990	1995	2000	2005	2008	2009	2010	2011	2012
1A. Fuel combustion	1,075,915	1,154,982	1,189,743	1,226,357	1,161,086	1,096,479	1,144,659	1,194,599	1,229,181
Liquid fuel CO_2	646,223	677,347	635,112	597,801	518,386	474,991	481,302	514,536	523,003
Solid fuel CO_2	308,620	331,720	376,520	437,937	420,521	401,558	431,474	413,571	431,097
Gaseous fuel CO_2	104,301	126,200	155,269	166,836	199,534	198,692	210,694	245,018	253,456
Other fuels CO_2 (Waste)	9,116	10,503	13,142	15,124	14,603	13,561	13,511	13,811	14,012
CH_4	887	964	957	911	887	861	957	936	920
N_2O	6,768	8,249	8,742	7,749	7,155	6,816	6,721	6,726	6,693
1B. Fugitive emissions from fuel	3,503	1,660	1,059	425	446	430	409	407	397
CO_2	37	51	36	38	38	35	33	33	32
CH_4	3,466	1,609	1,023	387	408	394	376	374	365
N_2O	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	1,079,418	1,156,642	1,190,802	1,226,782	1,161,533	1,096,909	1,145,068	1,195,006	1,229,578

2.3.2. Industrial Processes

Emissions from the industrial processes sector in FY2012 were 69.5 million tonnes (in CO_2 eq.). They decreased by 30.2% since FY1990, and increased by 3.5% compared to the previous year.

The breakdown of GHGs emissions from this sector in FY2012 shows that the largest source is the mineral products such as CO_2 emissions from limestone in the cement production accounting for 56%. It is followed by the consumption of HFCs (33%) and the consumption of PFCs (4%).

The main driving factors for decrease in emissions since FY1990 are the decrease in CO_2 emissions from cement production as the clinker production declined, the decrease in N_2O emissions from adipic acid production as the N_2O abatement equipment came on stream, and the decreases in PFCs and SF_6 emissions as the promotion of substitute materials use and of the capture and destruction of these gases.

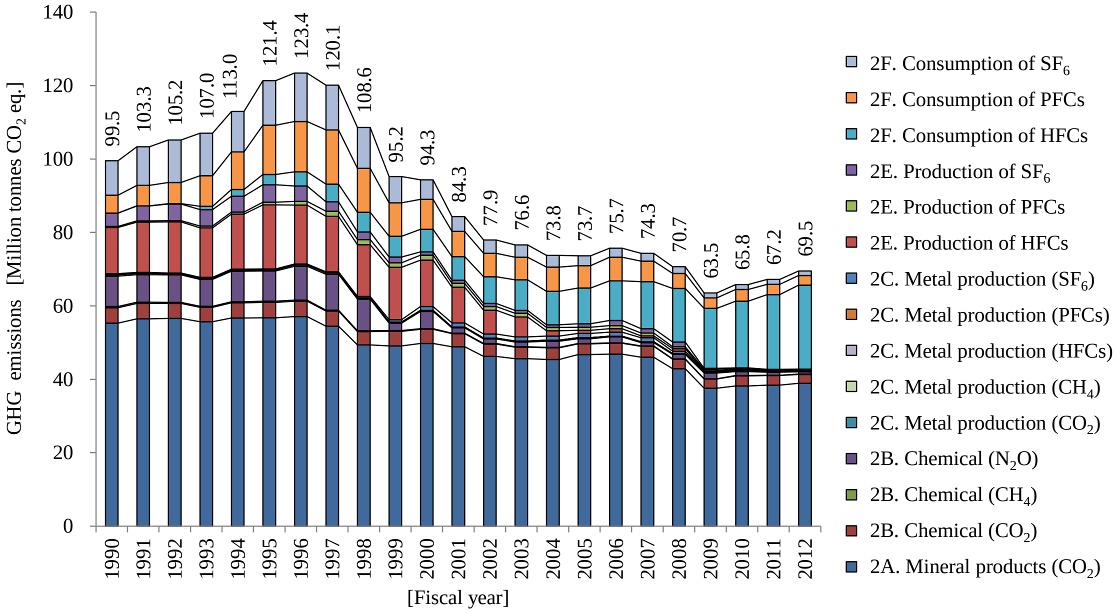

Figure 2-13 Trends in GHG emissions from the industrial processes sector

Table 2-10 Trends in GHG emissions from the industrial processes sector

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
2A. Mineral products (CO_2)	55,311	56,756	49,746	46,774	42,883	37,589	38,177	38,391	38,906
2B. Chemical industry	12,814	12,736	8,762	4,303	3,942	4,144	3,918	3,521	3,151
CO_2	4,209	4,220	3,893	2,887	2,574	2,488	2,737	2,629	2,416
CH_4	338	304	178	117	106	96	103	104	104
N_2O	8,267	8,213	4,690	1,300	1,262	1,559	1,078	788	631
2C. Metal production	666	564	1,311	1,431	838	375	493	379	391
CO_2	356	357	248	242	156	112	160	162	174
CH_4	19	18	17	17	15	13	15	15	15
HFCs	NO	NO	NO	NO	NO	NO	NO	1	1
PFCs	137	70	18	15	15	11	10	10	9
SF_6	154	120	1,028	1,157	652	239	308	191	191
2E. Production of F-gas	16,508	22,916	14,879	2,629	2,514	882	527	423	344
HFCs	12,594	17,445	12,660	816	702	222	128	113	92
PFCs	276	763	1,359	837	524	399	200	172	122
SF_6	3,638	4,708	860	975	1,288	261	198	139	129
2F. Consumption of F-gas	14,241	28,387	19,648	18,516	20,494	20,531	22,717	24,480	26,724
HFCs	2	2,815	6,141	9,702	14,597	16,324	18,163	20,338	22,832
PFCs	4,863	13,439	8,207	6,138	4,077	2,855	3,198	2,834	2,627
SF_6	9,376	12,134	5,300	2,676	1,821	1,352	1,356	1,308	1,265
Total	99,540	121,360	94,345	73,653	70,671	63,521	65,833	67,195	69,516

2.3.3. Solvent and Other Product Use

Emissions from the solvents and other product use sector in FY2012 were 90 thousand tonnes (in CO_2 eq.). They decreased by 68.4% since FY1990, and by 6.7% compared to the previous year. The only substance subject for estimation in this sector is laughing gas (N_2O) used as a general anesthetic in hospitals.

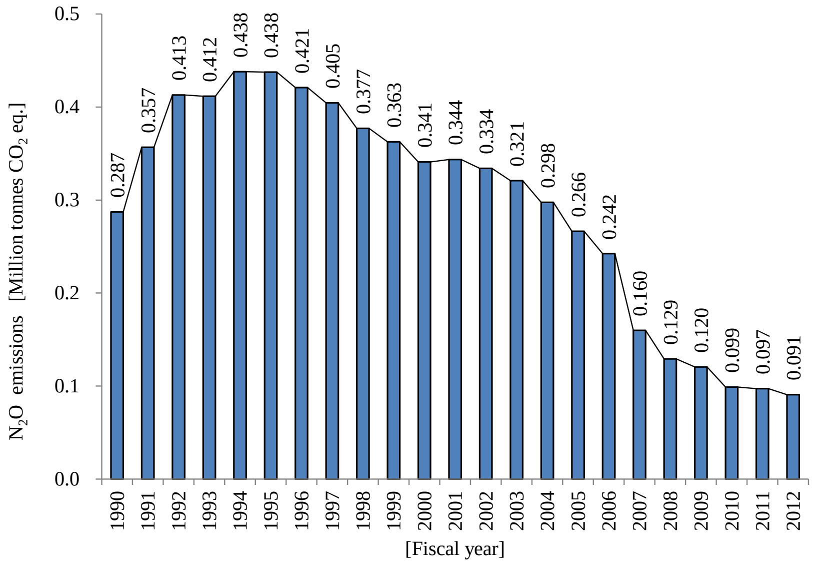

Figure 2-14 Trends in GHG emissions from the solvent and other product use sector

2.3.4. Agriculture

Emissions from the agriculture sector in FY2012 were 23.9 million tonnes (in CO_2 eq.). They decreased by 18.0% since FY1990 and by 0.5% compared to the previous year.

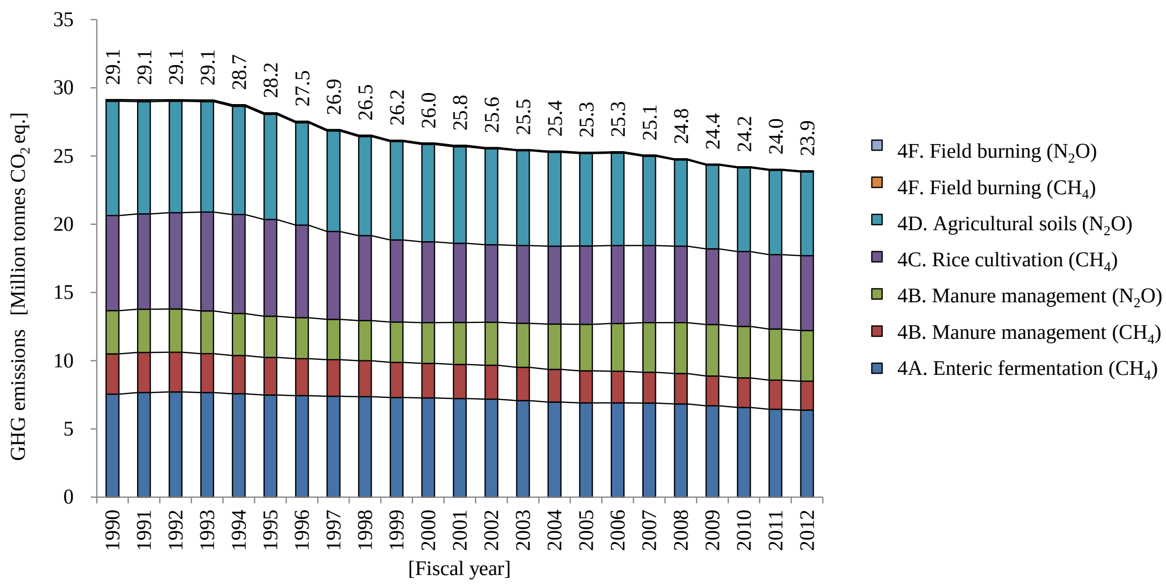

Figure 2-15 Trends in GHG emissions from the agriculture sector

Breakdown of the FY2012 emissions from this sector in shows that the largest source is the enteric fermentation accounting for 27%. It is followed by the agricultural Soils (26%) as a result of the nitrogen-based fertilizer applications, and the rice cultivation (23%).

The main driving factor for decrease in emissions since FY1990 is the decrease in CH_4 emissions from the rice cultivation as a result of crop acreage decline, and the decrease in N_2O emissions from the agricultural soils, because the amount of nitrogen fertilizers applied to cropland had decreased.

Table 2-11 Trends in GHG emissions from the agriculture sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
4A. Enteric fermentation(CH_4)	7,550	7,489	7,265	6,912	6,829	6,691	6,577	6,441	6,379
4B. Manure management	6,120	5,773	5,521	5,749	5,956	5,961	5,940	5,868	5,833
CH_4	2,949	2,752	2,538	2,347	2,223	2,185	2,162	2,134	2,121
N_2O	3,171	3,021	2,983	3,402	3,734	3,776	3,779	3,734	3,712
4C. Rice cultivation (CH_4)	6,960	7,083	5,920	5,739	5,599	5,545	5,477	5,460	5,480
4D. Agricultural soils (N_2O)	8,377	7,702	7,147	6,780	6,324	6,133	6,144	6,185	6,140
4F. Field burning of agricultural residues	128	120	99	84	79	75	72	72	72
CH_4	101	94	77	65	62	58	56	56	57
N_2O	27	26	22	18	17	16	16	16	16
Total	29,135	28,166	25,952	25,263	24,787	24,405	24,210	24,026	23,905

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

Net removals (including CO_2, CH_4 and N_2O emissions) from the LULUCF sector in FY2012 was 75.1 million tonnes (in CO_2 eq.). They increased by 12.3% since FY1990 and decreased by 0.7% compared to the previous year. The decline trend in removals in recent years is largely due to maturity of Japanese forest. The emissions from cropland and settlements have decreased since FY1990, because the land-use conversions to those land-use categories became less due to economic depression and the decline of agriculture, etc.

Breakdown of the FY2012 emissions and removals from this sector shows that the largest sink is the forest land and its removals were 77.7 million tonnes accounting for 103% of this sector's net total emissions / removals.

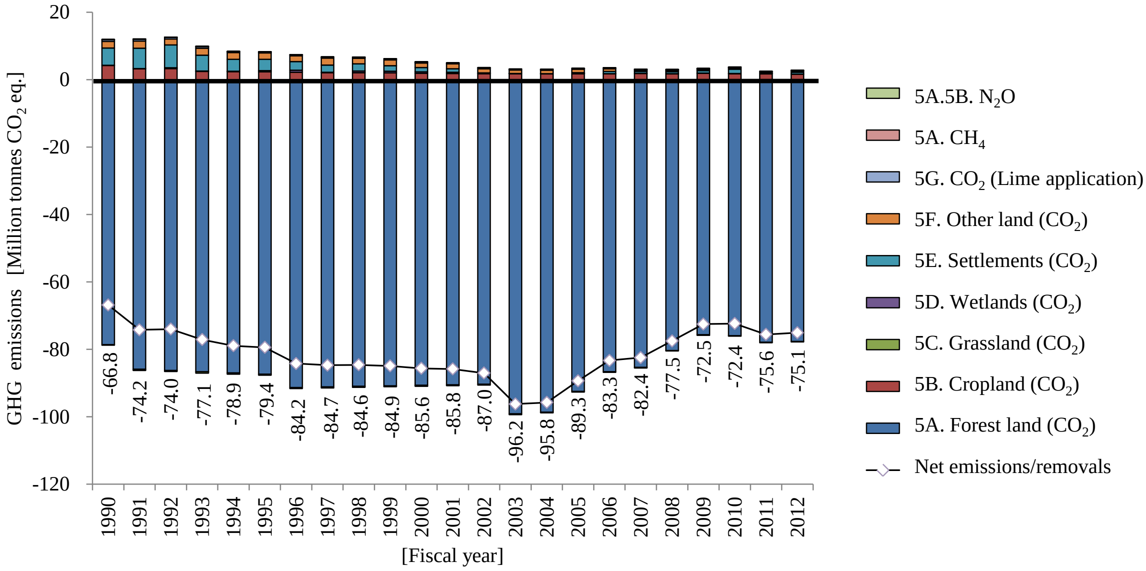

Figure 2-16 Trends in GHG emissions and removals from the LULUCF sector

Table 2-12 Trends in GHG emissions and removals from the LULUCF sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
5A. Forest land	-78,552	-87,319	-90,655	-92,458	-80,310	-75,665	-75,937	-77,911	-77,670
CO_2	-78,563	-87,330	-90,664	-92,469	-80,335	-75,675	-75,942	-77,918	-77,673
CH_4	9	9	8	9	22	9	4	5	2
N_2O	2	2	1	2	3	1	1	1	1
5B. Cropland	4,258	2,371	1,896	1,768	1,725	1,868	1,763	1,714	1,645
CO_2	4,188	2,322	1,867	1,754	1,716	1,861	1,758	1,709	1,641
CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
N_2O	70	49	29	13	9	7	6	5	4
5C. Grassland	-231	-340	-282	-201	-161	-139	-112	-133	-116
CO_2	-231	-340	-282	-201	-161	-139	-112	-133	-116
CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5D. Wetlands	91	360	429	15	35	73	51	44	32
CO_2	91	360	429	15	35	73	51	44	32
CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5E. Settlements	5,116	3,377	1,280	315	579	767	1,292	156	508
CO_2	5,116	3,377	1,280	315	579	767	1,292	156	508
CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
5F. Other land	1,950	1,837	1,351	1,000	328	319	341	295	289
CO_2	1,950	1,837	1,351	1,000	328	319	341	295	289
CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
5G. Other	550	304	333	231	306	270	243	247	247
CO_2	550	304	333	231	306	270	243	247	247
Total	-66,818	-79,410	-85,648	-89,330	-77,500	-72,507	-72,357	-75,588	-75,065

2.3.6. Waste

Emissions from the waste sector in FY2012 were 20.0 million tonnes (in CO_2 eq.). They decreased by 22.8% since FY1990 and by 0.8% compared to the previous year.

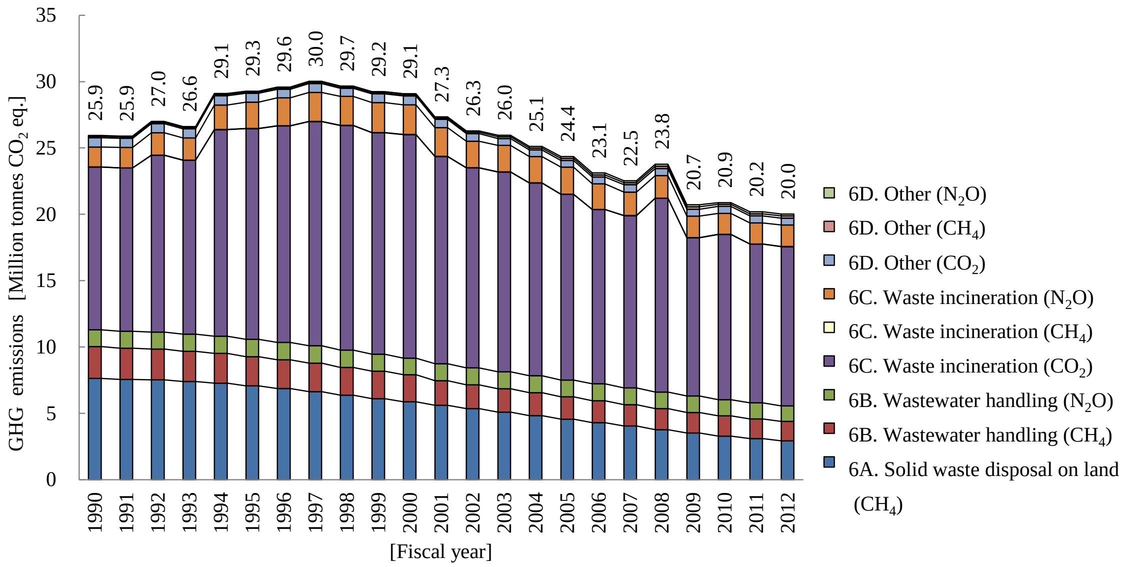

Figure 2-17 Trends in GHG emissions from the waste sector

Breakdown of the FY2012 emissions from this sector shows that the largest source is the waste incineration (CO_2), associated with waste derived from fossil fuels such as waste plastic and waste oil, accounting for 60%. It is followed by the solid waste disposal on land (CH_4) (15%) and the waste incineration (N_2O) (8%), associated with waste substances including those that do not have a fossil fuel origin.

The main driving factor for decrease in emissions since FY1990 is the decrease in CH_4 emissions from the 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 and other acts.

Table 2-13 Trends in GHG emissions from the waste sector

[Thousand tonnes CO_2 eq.]

Category	1990	1995	2000	2005	2008	2009	2010	2011	2012
6A. Solid waste disposal on land (CH_4)	7,637	7,070	5,875	4,568	3,767	3,525	3,292	3,096	2,928
6B. Wastewater handling	3,658	3,514	3,286	2,948	2,844	2,781	2,738	2,704	2,639
CH_4	2,402	2,207	2,043	1,685	1,592	1,545	1,517	1,491	1,464
N_2O	1,256	1,307	1,244	1,263	1,253	1,236	1,221	1,213	1,175
6C. Waste incineration	13,769	17,863	19,093	16,041	16,311	13,566	14,039	13,551	13,636
CO_2	12,263	15,867	16,838	13,984	14,606	11,922	12,452	11,956	12,000
CH_4	13	15	13	14	12	10	10	10	8
N_2O	1,493	1,981	2,242	2,042	1,694	1,633	1,577	1,585	1,628
6D. Other	876	836	828	800	861	846	816	843	826
CO_2	703	668	656	507	530	514	527	524	515
CH_4	92	89	91	155	175	176	153	169	165
N_2O	81	79	81	138	155	156	136	150	146
Total	25,941	29,283	29,082	24,357	23,783	20,718	20,885	20,193	20,029

2.4. Description and Interpretation of Emission Trends for Indirect GHGs and SO_2

Under the UNFCCC, it is required to report emissions not only 6 types of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) that are controlled by the Kyoto Protocol, but also emissions of indirect GHGs (NO_X, CO and NMVOC) as well as SO_2. Their emission trends are indicated below.

Nitrogen oxide (NO_X) emissions in FY2012 were 1,627 thousand tonnes. They decreased by 20.4% since FY1990 and by 2.9% compared to the previous year.

Carbon monoxide (CO) emissions in FY2012 were 2,502 thousand tonnes. They decreased by 44.2% since FY1990 and increased by 0.8% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY2012 were 1,538 thousand tonnes. They decrease by 20.9% since FY1990 and by 1.2% compared to the previous year.

Sulfur dioxide (SO_2) emissions in FY2012 were 937 thousand tonnes. They decreased by 25.3% since FY1990 and by 0.6% compared to the previous year.

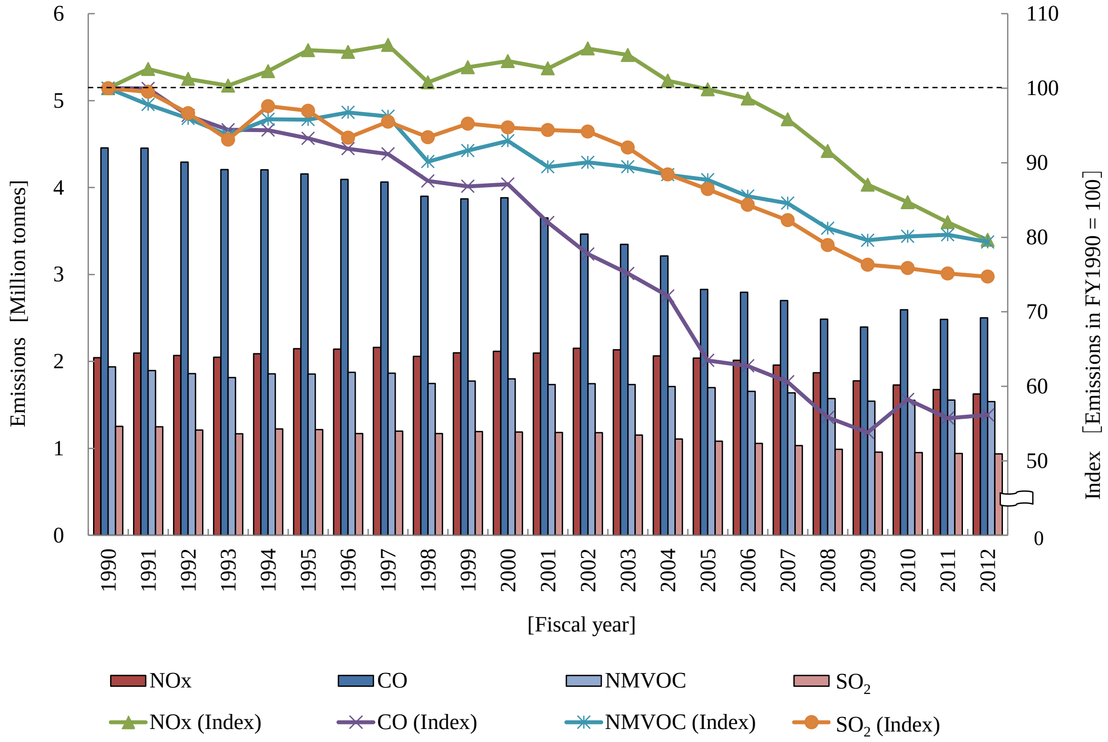

Figure 2-18 Trends in emissions of indirect GHGs and SO_2

2.5. Emissions and removals from KP-LULUCF activities

The net removals from KP-LULUCF activities in FY2012 were 52.8 million tonnes (in CO_2 eq.). The breakdown of emissions and removals to each activity in the first commitment period of the Kyoto Protocol is shown in Table 2-14. For detailed information, see Chapter 11.

Table 2-14 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	Net emissions/removals 2008	2009	2010	2011	2012	Total	Accounting parameters	Accounting quantity
	(Gg CO_2 equivalent)								
A. Article 3.3 activities									
A.1. Afforestation and Reforestation									-2320.58
A.1.1. Units of land not harvested since the beginning of the commitment period		-426.28	-447.99	-469.67	-482.25	-494.39	-2,320.58		-2320.58
A.1.2. Units of land harvested since the beginning of the commitment period									
A.2. Deforestation		2,167.75	2,646.75	3,036.04	1,632.98	1,954.89	11,438.42		11438.42
B. Article 3.4 activities									
B.1. Forest management (if elected)		-46,363.73	-48,096.39	-50,931.50	-51,638.70	-53,140.34	-250,170.66		-247451.17
3.3 offset								9,117.84	-9117.84
FM cap								238,333.33	-238333.33
B.2. Cropland management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	-77.82	-1079.70	-1110.88	-1128.66	-1142.08	-1161.85	-5623.17	-389.12	-5234.05

※ Japan's actual net removals by FM after application of 3.3 offset for the first commitment period of the Kyoto Protocol exceeded the upper limit given to Japan in the appendix to decision 16/CMP.1, which was 13 Mt-C times 5 (238,333 Gg-CO_2). Therefore, Japan accounted for the removals by the upper limit.

※ Since the total anthropogenic GHG emissions by sources and removals by sinks in managed forests since 1990 are larger than the net source of emissions incurred under Article 3.3, the offset rule according to paragraph 10 of the annex to decision 16/CMP.1 is applied to Japan.

※ 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.*
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5. Ministry of the Environment, Committee for the Greenhouse Gases Emissions Estimation Methods, *GHGs Estimation Methods Committee Report*, February 2006.

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 FY2012, GHG emissions (CO_2, CH_4 and N_2O) from the energy sector accounted for 1,229,578 Gg-CO_2 eq., and represented 91.5% of Japan's total GHG emissions (excluding LULUCF). The emissions from the energy sector had increased by 13.9% compared to FY1990.

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 aviation, railways, road transport and shipping; other sectors (1.A.4):— emissions from commercial/institutional, residential, and agriculture/forestry/fishing sources; and other (1.A.5):— emissions from other sectors.

In FY2012, emissions from fuel combustion were 1,229,181 Gg-CO_2 eq., and represented 91.5% of Japan's total GHG emissions (excluding LULUCF). Since 1990, the emissions had increased by 14.2%, led by the increases in emissions from energy industries (1.A.1) by 187,201 Gg-CO_2 eq. (57.6%) and from transport (1.A.3) by 4,186 Gg-CO_2 eq. (1.9%), while the emissions from manufacturing industries and construction (1.A.2) had decreased by 37,441 Gg-CO_2 eq. (10.0%). The major reasons of these increases and decreases from 1990 are the increase of fossil fuel consumption in public electricity and heat production (1.A.1.a) due to electricity consumption increase, the increase of traffic demand of cars in road transportation (1.A.3.b), on the other hand the decreases of the production demand and the fuel consumption due to the Global Financial Crisis and the East Japan Great Earthquake in recent years and the change of fuel type from liquid to gaseous in manufacturing industries such as chemicals (1.A.2.c), other/cement and ceramics (1.A.2.f), and other/machinery (1.A.2.f).

GHG emissions from fuel combustion in FY2012 had increased by 2.9% compared to FY2011. The primary reason for the emission increase in FY2012 as compared to FY2011 was the increase of CO_2 emissions from electric power generation in the energy industries due to the increase of fossil fuel consumption at the thermal power plants.

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

Gas	Item		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	1.A.1. Energy industries	a. Public electricity and heat production	Gg-CO_2	297,074	315,399	330,863	378,921	395,340	356,702	379,340	439,704	485,184
		b. Petroleum refining	Gg-CO_2	15,893	16,956	17,285	16,441	14,324	14,564	15,038	14,064	13,745
		c. Manufacture of solid fuels and other energy industries	Gg-CO_2	11,286	12,592	9,426	10,677	11,225	14,227	10,994	13,167	11,334
	1.A.2. Manufacturing industries and construction	a. Iron and steel	Gg-CO_2	149,600	141,862	150,776	152,741	143,269	134,610	151,892	147,767	149,983
		b. Non-ferrous metals	Gg-CO_2	6,092	4,770	3,042	2,634	2,333	2,120	2,075	1,974	1,889
		c. Chemicals	Gg-CO_2	64,736	74,806	67,216	58,650	53,325	52,549	53,588	52,420	50,096
		d. Pulp, paper and print	Gg-CO_2	25,825	29,449	29,035	26,553	22,845	21,242	20,329	20,805	20,950
		e. Food processing, beverages and tobacco	Gg-CO_2	13,129	14,407	13,161	11,326	8,862	8,826	8,974	8,538	8,236
		f. Other	Gg-CO_2	111,929	105,245	113,547	119,326	104,987	99,746	105,800	103,378	101,941
	1.A.3. Transport	a. Civil aviation	Gg-CO_2	7,162	10,278	10,677	10,799	10,277	9,781	9,193	9,001	9,524
		b. Road transportation	Gg-CO_2	189,228	225,389	232,885	222,851	206,180	202,289	205,025	201,417	196,380
		c. Railways	Gg-CO_2	935	822	711	647	604	590	574	555	554
		d. Navigation	Gg-CO_2	13,731	14,687	14,865	12,915	11,288	10,383	10,716	10,586	10,850
	1.A.4. Other sectors	a. Commercial/institutional	Gg-CO_2	83,590	93,259	101,388	110,476	98,506	92,932	91,877	94,093	91,426
		b. Residential	Gg-CO_2	56,668	66,320	68,958	67,583	59,023	57,792	61,074	58,941	58,324
		c. Agriculture/forestry/fisheries	Gg-CO_2	21,380	19,526	16,207	15,158	10,657	10,449	10,495	10,526	11,152
	1.A.5 Other	a. Stationary	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		Gg-CO_2	1,068,260	1,145,769	1,180,044	1,217,697	1,153,045	1,088,802	1,136,981	1,186,937	1,221,568
CH_4	1.A.1. Energy industries	a. Public electricity and heat production	Gg-CH_4	1.35	1.55	1.90	1.36	1.32	1.24	1.80	3.08	3.50
		b. Petroleum refining	Gg-CH_4	0.05	0.06	0.07	0.08	0.07	0.07	0.08	0.08	0.10
		c. Manufacture of solid fuels and other energy industries	Gg-CH_4	0.02	0.03	0.06	0.06	0.10	0.10	0.11	0.11	0.13
	1.A.2. Manufacturing industries and construction	a. Iron and steel	Gg-CH_4	4.59	4.22	4.88	6.40	7.23	7.12	8.33	8.23	8.60
		b. Non-ferrous metals	Gg-CH_4	0.29	0.25	0.19	0.15	0.13	0.12	0.12	0.11	0.11
		c. Chemicals	Gg-CH_4	0.22	0.27	0.33	0.67	1.18	1.35	1.59	1.58	1.50
		d. Pulp, paper and print	Gg-CH_4	1.10	1.08	1.13	1.47	1.94	1.89	2.06	2.02	1.98
		e. Food processing, beverages and tobacco	Gg-CH_4	0.11	0.14	0.12	0.09	0.06	0.06	0.07	0.07	0.07
		f. Other	Gg-CH_4	10.60	11.39	10.24	9.66	10.31	10.23	12.43	12.35	11.41
	1.A.3. Transport	a. Civil aviation	Gg-CH_4	0.14	0.17	0.21	0.23	0.22	0.22	0.22	0.22	0.24
		b. Road transportation	Gg-CH_4	12.57	13.00	12.47	9.69	7.63	7.14	6.64	6.26	6.08
		c. Railways	Gg-CH_4	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.03	0.03
		d. Navigation	Gg-CH_4	1.27	1.37	1.41	1.23	1.07	0.98	1.01	1.00	1.01
	1.A.4. Other sectors	a. Commercial/institutional	Gg-CH_4	1.02	3.18	4.09	4.33	4.17	3.80	4.07	2.64	2.45
		b. Residential	Gg-CH_4	8.23	8.61	8.15	7.76	6.64	6.49	6.89	6.65	6.49
		c. Agriculture/forestry/fisheries	Gg-CH_4	0.63	0.52	0.30	0.19	0.13	0.13	0.13	0.13	0.13
	1.A.5 Other	a. Stationary	Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		Gg-CH_4	42.25	45.89	45.57	43.39	42.23	40.99	45.58	44.57	43.83
			Gg-CO_2 eq.	887	964	957	911	887	861	957	936	920
N_2O	1.A.1. Energy industries	a. Public electricity and heat production	Gg-N_2O	2.88	4.40	5.27	6.44	6.27	5.99	5.92	6.40	6.39
		b. Petroleum refining	Gg-N_2O	0.08	0.14	0.20	0.20	0.19	0.19	0.20	0.19	0.19
		c. Manufacture of solid fuels and other energy industries	Gg-N_2O	0.02	0.02	0.02	0.03	0.06	0.06	0.07	0.07	0.08
	1.A.2. Manufacturing industries and construction	a. Iron and steel	Gg-N_2O	1.08	1.31	1.36	1.39	1.45	1.37	1.39	1.39	1.42
		b. Non-ferrous metals	Gg-N_2O	0.19	0.18	0.14	0.03	0.02	0.02	0.02	0.02	0.02
		c. Chemicals	Gg-N_2O	0.58	1.05	1.03	0.80	0.69	0.69	0.71	0.68	0.67
		d. Pulp, paper and print	Gg-N_2O	0.48	0.90	0.93	0.95	1.12	1.16	1.16	1.19	1.20
		e. Food processing, beverages and tobacco	Gg-N_2O	0.24	0.26	0.26	0.25	0.24	0.24	0.24	0.24	0.23
		f. Other	Gg-N_2O	1.79	2.21	3.10	3.15	2.88	2.71	2.89	2.83	2.87
	1.A.3. Transport	a. Civil aviation	Gg-N_2O	0.23	0.30	0.34	0.35	0.33	0.32	0.30	0.29	0.31
		b. Road transportation	Gg-N_2O	12.63	13.98	13.70	9.66	8.22	7.72	7.21	6.83	6.57
		c. Railways	Gg-N_2O	0.39	0.34	0.29	0.27	0.25	0.24	0.23	0.23	0.23
		d. Navigation	Gg-N_2O	0.36	0.39	0.40	0.35	0.30	0.28	0.29	0.28	0.29
	1.A.4. Other sectors	a. Commercial/institutional	Gg-N_2O	0.38	0.59	0.68	0.72	0.72	0.69	0.72	0.74	0.81
		b. Residential	Gg-N_2O	0.29	0.33	0.34	0.33	0.27	0.26	0.28	0.27	0.26
		c. Agriculture/forestry/fisheries	Gg-N_2O	0.21	0.21	0.13	0.08	0.05	0.05	0.05	0.05	0.05
	1.A.5 Other	a. Stationary	Gg-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
		b. Mobile	Gg-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Total		Gg-N_2O	21.83	26.61	28.20	25.00	23.08	21.99	21.68	21.70	21.59
			Gg-CO_2 eq.	6,768	8,249	8,742	7,749	7,155	6,816	6,721	6,726	6,693
Total of all gases			Gg-CO_2 eq.	1,075,915	1,154,982	1,189,743	1,226,357	1,161,086	1,096,479	1,144,659	1,194,599	1,229,181

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

a) *Source/Sink 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 FY2012, CO_2 emissions from this category accounted for 510,263 Gg-CO_2, and represented 38.0% of Japan's total GHG emissions (excluding LULUCF). As for breakdown of GHG emissions within the fuel combustion category in FY2012, public electricity and heat production (1.A.1.a) accounts for 95.1%, and is followed by petroleum refining (1.A.1.b) (2.7%) and manufacture of solid fuels and other energy industries (1.A.1.c) (2.2%).

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[2]. 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, CO_2 emissions were increased due to an increase in the share of thermal power generation, while power generation was decreased.

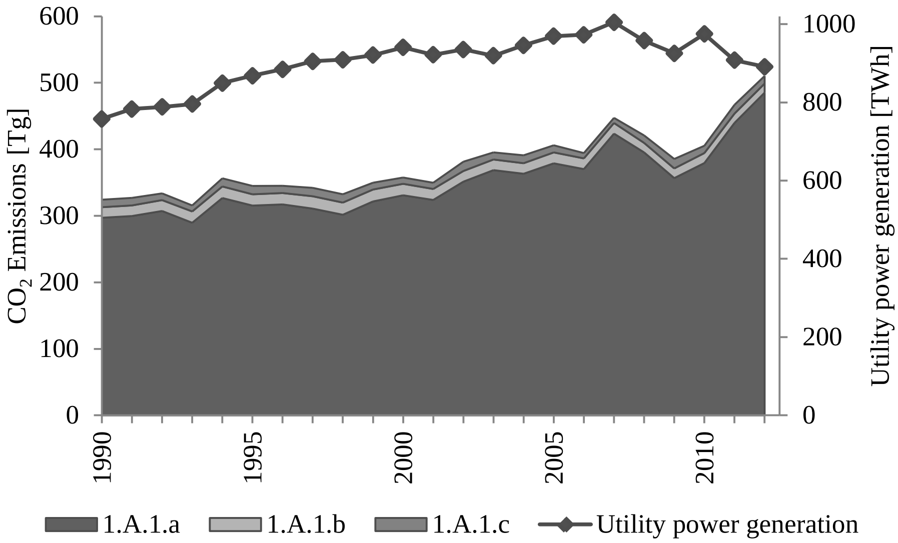

Figure 3-1 The trends of CO_2 emissions from Energy Industries (1.A.1) and related indicator

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.

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

b) *Methodological Issues*

- ***Estimation Method***

The Tier 1 Sectoral Approach has been used in accordance with the decision tree of the *GPG (2000)* to calculate emissions (Page 2.10, Fig. 2.1). 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 product 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 quantities of heat and emissions from waste incineration with energy recovery are reported in fuel combustion (1.A.) as "other fuels" in accordance with the *1996 Revised IPCC Guidelines* and the *GPG (2000)*.

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 (6.C.) in accordance with the *1996 Revised IPCC Guidelines*. Please refer to Chapter 8 for further details on the estimation methods.

- ***Emission Factors***

➢ *Carbon emission factors*

The carbon content of fuels expressed as the unit of calorific value (Gross Calorific 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 3-2 provides the emission factors for CO_2 by fuel types.

Table 3-2 Emission factors for fuel combustion in gross calorific value (Unit: t-C/TJ)

	Fuel	Code [1]	1990	1995	2000	2005	2008	2009	2010	2011	2012	References
Coal	Steel making coal	$110	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	-
	Coking coal	$111	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	2006 IPCC Guidelines for National Greenhouse Gas Inventories
	PCI coal	$112	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	Same as coking coal
	Imported steam coal	$130	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	-
	Imported coal: for general use	$131	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Imported coal: for power generation	$132	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	24.7	Same as imported coal : for general use
	Indigenous steam coal	$135	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Underground	$136	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	Same as indigenous steam coal
	Open pit	$137	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	24.9	Same as indigenous steam coal
	Hard coal, anthracite & lignite	$140	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	25.5	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Coal products	Coke	$161	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Coal tar	$162	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	20.9	2006 IPCC Guidelines for National Greenhouse Gas Inventories
	Coal briquette	$163	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Coke oven gas	$171	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	2006 IPCC Guidelines for National Greenhouse Gas Inventories
	Blast furnace gas	$172	27.3	26.9	26.6	26.5	26.4	26.5	26.3	26.3	26.1	Established with annually calculated values in order to keep the carbon balance in blast furnace and L.D. converter
	Converter furnace gas	$175	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	2006 IPCC Guidelines for National Greenhouse Gas Inventories
Oil	Crude oil for refinery	$210	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Crude oil for power generation	$220	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Bituminous mixture fuel	$221	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	2006 IPCC Guidelines for National Greenhouse Gas Inventories
	Natural gas liquid & condensate	$230	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	18.4	GHGs Estimation Methods Committee Report (Ministry of the Environment, Committee for the Greenhouse Gases Emissions Estimation Methods)
Oil products	Slack gasoline	$271	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	Adopted the value of naphtha
	Slack kerosene	$272	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	Adopted the value of kerosene
	Slack diesel oil or gas oil	$273	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Adopted the value of diesel oil or gas oil
	Slack fuel oil	$274	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	Adopted the value of fuel oil C
	Cracked gasoline	$275	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	Adopted the value of naphtha
	Cracked diesel oil or gas oil	$276	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Adopted the value of diesel oil or gas oil
	Feedstock oil for refinery and mixing	$277	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Adopted the value of crude oil for refinery
	Naphtha	$281	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Reformed material oil	$282	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	Adopted the value of gasoline
	Gasoline	$310	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Premium gasoline	$311	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	Same as gasoline
	Regular gasoline	$312	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	Same as gasoline
	Jet fuel	$320	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	18.3	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Kerosene	$330	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Gas oil or diesel oil	$340	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Fuel oil A	$351	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	18.9	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Fuel oil C	$355	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Fuel oil B	$356	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	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	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Fuel oil C for power generation	$358	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Lubricating oil	$365	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.2	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Asphalt	$371	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Non asphalt heavy oil products	$372	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Oil coke	$375	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	25.4	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Galvanic furnace gas	$376	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	38.4	Adopted the value of converter furnace gas
	Refinery gas	$380	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.2	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Liquefied petroleum gas	$390	16.3	16.3	16.3	16.1	16.1	16.1	16.1	16.1	16.1	Environmental Agency, The Report on Estimation of CO2 Emissions in Japan, after 2005: GHGs Estimation Methods Committee Report (Ministry of the Environment, Committee for the Greenhouse Gases Emissions Estimation Methods)
Natural gas	Liquefied natural gas	$410	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Indigenous natural gas	$420	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	2006 IPCC Guidelines for National Greenhouse Gas Inventories
	Indigenous natural gas	$421	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	Adopted the value of indigenous natural gas
	Coal mining gas	$422	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5	Environmental Agency, The Report on Estimation of CO_2 Emissions in Japan
	Off-gas from crude oil	$423	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	Adopted the value of indigenous natural gas
Town gas	Town gas	$450	14.0	14.0	13.8	13.6	13.7	13.6	13.7	13.8	13.7	Same as town gas
	Town gas	$460	14.0	14.0	13.8	13.6	13.7	13.6	13.7	13.8	13.7	Established with annually calculated values in order to keep the carbon balance in prodeced town gas
	Small-scale town gas	$470	16.3	16.3	16.3	16.1	16.1	16.1	16.1	16.1	16.1	Adopted the value of liquified petroleum gas

(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 those 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)" and "*2006 IPCC Guidelines*".

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[3] 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.

The values assessed as inadequate were substituted by the values given in the *GHGs Estimation Methods Committee Report* (Committee for the Greenhouse gases Emissions Estimation Methods,

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

Ministry of the Environment) and the *2006 IPCC Guidelines*.

(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 PCI (Pulverized Coal Injection) coal which are injected to the processes and those contained in BFG and CFG (Converter Furnace Gas) 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

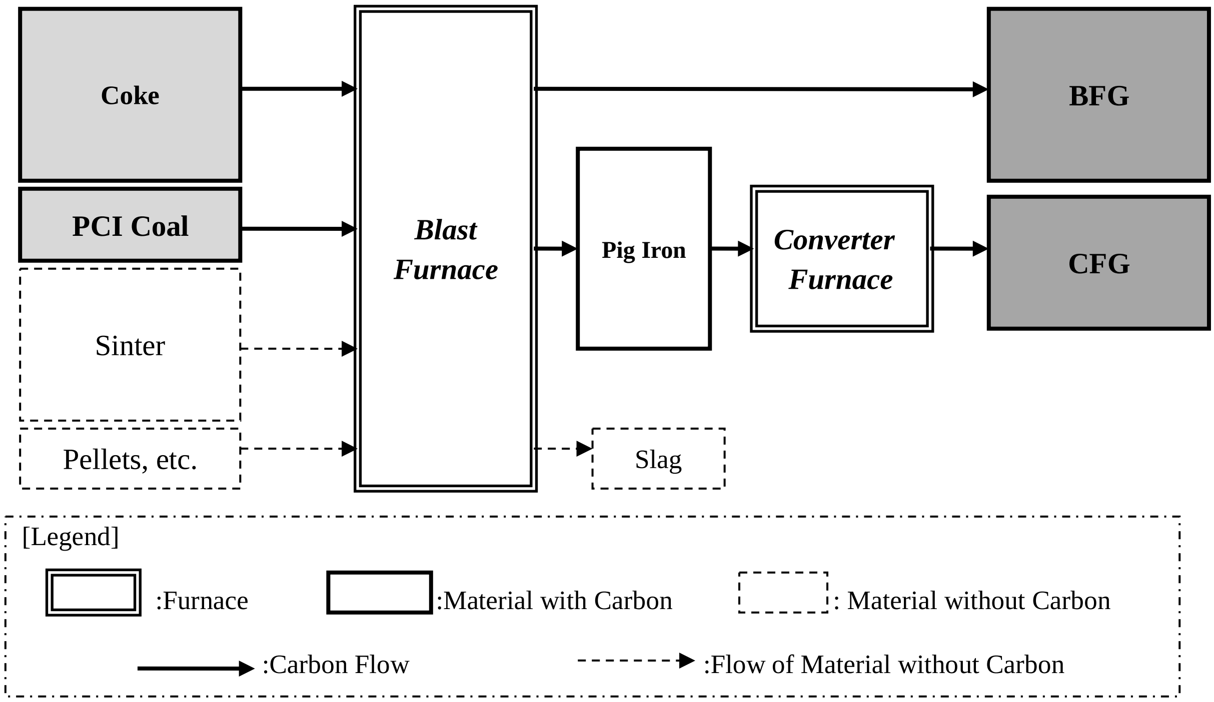

Figure 3-2 Overview of carbon flow for iron & steel manufacturing

Table 3-3 Calculation of emission factors for BFG

Steel process gas		1990	1995	2000	2005	2008	2009	2010	2011	2012	Note
Input											
PCI coal	Gg-C	1,574	2,593	3,518	3,111	2,950	2,659	3,550	3,776	4,134	A
Coke	Gg-C	12,830	11,432	12,021	11,382	10,818	10,358	11,067	10,008	10,049	B
Input total	Gg-C	14,404	14,024	15,539	14,492	13,768	13,017	14,616	13,784	14,183	C: A + B
Output											
CFG (LDG)	Gg-C	2,541	2,359	2,726	2,804	2,727	2,589	2,798	2,502	2,612	D
Difference	Gg-C	11,863	11,665	12,813	11,688	11,041	10,428	11,818	11,282	11,571	E: C - D
Output											
BFG	TJ	434,801	433,504	481,768	441,357	417,636	393,685	448,708	429,625	442,758	F
EF BFG	t-C/TJ	27.3	26.9	26.6	26.5	26.4	26.5	26.3	26.3	26.1	E / F

(c) Town gas

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

Small-scale town gas suppliers:
Because most of the small-scale town gas is LPG, the same emission factor was adopted as for LPG.

Town gas suppliers:
Town 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)

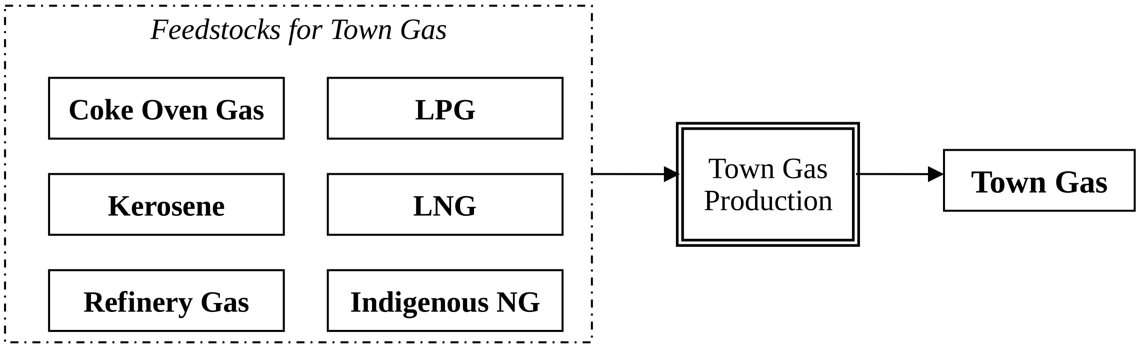

Figure 3-3 Manufacturing Flow for Town Gas

Table 3-4 Calculation of emission factors for town gas

Town gas production		1990	1995	2000	2005	2008	2009	2010	2011	2012	Note
Input											
COG	Gg-C	211	134	105	22	0	0	0	0	0	a1
Kerosene	Gg-C	200	275	69	6	0	0	0	0	0	a2
Refinery gas	Gg-C	186	199	186	145	88	13	0	0	0	a3
LPG	Gg-C	1,931	2,104	1,791	1,069	679	700	782	851	873	a4
LNG	Gg-C	6,253	9,107	11,642	16,563	19,378	19,181	20,919	21,435	21,416	a5
Indigenous NG	Gg-C	551	661	848	1,190	1,822	1,768	1,603	1,775	1,683	a6
Input total	Gg-C	9,331	12,480	14,641	18,994	21,967	21,663	23,304	24,062	23,971	A: Σ a
Output											
Town gas	TJ	664,661	892,307	1,061,122	1,391,962	1,607,991	1,593,032	1,697,063	1,745,748	1,755,849	B
EF Town gas	t-C/TJ	14.0	14.0	13.8	13.6	13.7	13.6	13.7	13.8	13.7	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 3-5 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 (Petroleum 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 3-6 shows the trend of energy consumption.

Table 3-6 Energy consumptions in Energy Industries (1.A.1) (unit: PJ)

Fuel 1)	1990	1995	2000	2005	2008	2009	2010	2011	2012
Liquid Fuels	2,241	1,838	1,181	1,164	1,177	774	852	1,405	1,698
Solid Fuels	1,008	1,422	1,839	2,462	2,386	2,313	2,418	2,311	2,449
Gaseous Fuels	1,553	1,776	2,157	2,036	2,471	2,467	2,589	3,238	3,450
Biomass	NO	NO	NO	26	26	23	43	80	90
Other Fuels	196	219	258	284	266	247	246	243	250
Total	4,998	5,255	5,436	5,973	6,325	5,823	6,149	7,277	7,938

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* (Energy Balance Table) 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, new and renewable energy, large-scale hydropower, 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 conversion (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 energy supply and demand modules.

(3) Preparing original unit tables (integrating modules and preparing a main table and a summary table) (units in t, kl, m^3, etc).

(4) Preparing energy unit tables (Units are 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 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/info/statistics/jukyu/result-2.htm (Japanese version only)

Please refer to the simplified energy balance tables provided in Annex 2 (A2.2).

For the activity data for energy industries, the data reported in the following sectors in the *General Energy Statistics* were used: "power generation, general electric utilities” [#2110][4] which reports energy consumption associated with electric power generation by electric power suppliers, “power generation, independent power producing” [#2150]; “district heat supply” [#2350] which provides

[4] Numbers in parentheses indicate the corresponding sector numbers in the *General Energy Statistics*

energy consumption associated with heat energy and cold energy by thermal energy suppliers; "own use, general electric utilities" [#2911] which reports energy consumption associated with captive (own) use of energy industries; "own use, independent power producing" [#2912]; "own use, district heat supply" [#2913]; "own use, oil refinery" [#2916]; "own use, town gas" [#2914]; "own use, steel coke" [#2915]; and "own use, other conversion" [#2917].

Table 3-7 shows the correspondence between the sectors of Japan's Energy Balance Table from the *General Energy Statistics* and those of the CRF.

Table 3-7 Correspondence between sectors of Japan's Energy Balance Table and those of the CRF (1.A.1)

CRF			Japan's Energy Balance Table	
1A1		Energy industries		
	1A1a	Public electricity and heat production	Power generation, general electric utilities	#2110
			Own use, general electric utilities	#2911
			Power generation, independent power production	#2150
			Own use, independent power production	#2912
			District heat supply	#2350
			Own use, district heat supply	#2913
	1A1b	Petroleum refining	Own use, oil refinery	#2916
	1A1c	Manufacture of solid fuels and other energy industries	Coal products	#2500
			Own use, town gas	#2914
			Own use, steel coke	#2915
			Own use, other conversion	#2917

➢ *Gross calorific value*

The gross calorific values used in Japan's Energy Balance Table (*General Energy Statistics*) are adopted. Table 3-8 shows the trends in gross calorific value for each fuel type. Japan's Energy Balance Table (*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 relevant official statistics and documents are adopted. The "standard calorific values" are revised approximately once in every 5 years.

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.

➢ *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 2 (A2.1).

Table 3-8 Trends in gross calorific value of each fuel type

Fuel		Code	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Coal	Steel making coal	$110	MJ/kg	31.8	31.8	28.9	29.0	29.0	29.0	29.0	29.0	29.0
	Coking coal	$111	MJ/kg	31.8	30.5	29.1	29.1	29.1	29.1	29.1	29.1	29.1
	PCI coal	$112	MJ/kg	31.8	30.5	28.2	28.2	28.2	28.2	28.2	28.2	28.2
	Imported steam coal	$130	MJ/kg	26.0	26.0	26.6	25.7	25.7	25.7	25.7	25.7	25.7
	Imported 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
	Imported coal : for power generation	$132	MJ/kg	24.9	26.1	26.4	25.5	25.3	25.4	25.3	25.3	25.3
	Indigenous steam coal	$135	MJ/kg	24.3	24.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5
	Underground	$136	MJ/kg	24.3	24.3	23.2	23.2	23.2	23.2	23.2	23.2	23.2
	Open pit	$137	MJ/kg	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7	18.7
	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
Coal Products	Coke	$161	MJ/kg	30.1	30.1	30.1	29.4	29.4	29.4	29.4	29.4	29.4
	Coal tar	$162	MJ/kg	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
	Coke oven gas	$171	MJ/m^{3}N	21.5	21.6	21.3	21.4	21.2	21.1	21.3	21.1	20.7
	Blast furnace gas	$172	MJ/m^{3}N	3.5	3.6	3.6	3.4	3.4	3.4	3.4	3.4	3.4
	Converter furnace gas	$175	MJ/m^{3}N	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
Oil	Crude oil for refinery	$210	MJ/l	38.3	38.3	38.2	38.1	38.2	38.1	38.2	38.2	38.1
	Crude oil for power generation	$220	MJ/l	39.1	39.2	39.6	38.5	39.5	39.7	39.7	39.4	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
	Natural gas liquid & condensate	$230	MJ/l	35.7	35.5	35.4	35.0	32.9	34.8	34.8	36.9	34.8
Oil Products	Slack gasoline	$271	MJ/l	33.6	33.6	33.6	33.5	33.5	33.5	33.5	33.5	33.5
	Slack kerosene	$272	MJ/l	36.8	36.8	36.8	36.7	36.7	36.7	36.7	36.7	36.7
	Slack diesel oil or gas oil	$273	MJ/l	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6
	Slack fuel oil	$274	MJ/l	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.9	41.8
	Cracked gasoline	$275	MJ/l	33.6	33.6	33.6	33.5	33.5	33.5	33.5	33.5	33.5
	Cracked diesel oil or gas oil	$276	MJ/l	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6	38.6
	Feedstock oil for refinery and mixing	$277	MJ/l	38.3	38.3	38.2	38.1	38.2	38.1	38.2	38.2	38.1
	Naphtha	$281	MJ/l	33.6	33.6	33.6	33.5	33.5	33.5	33.5	33.5	33.5
	Reformed material oil	$282	MJ/l	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1
	Gasoline	$310	MJ/l	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6	34.6
	Premium gasoline	$311	MJ/l	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1	35.1
	Regular gasoline	$312	MJ/l	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5
	Jet fuel	$320	MJ/l	36.4	36.4	36.7	36.7	36.7	36.7	36.7	36.7	36.7
	Kerosene	$330	MJ/l	36.8	36.8	36.8	36.7	36.7	36.7	36.7	36.7	36.7
	Gas oil or diesel oil	$340	MJ/l	38.1	38.1	38.2	37.8	37.9	37.9	38.1	38.0	37.9
	Fuel oil A	$351	MJ/l	39.7	39.6	39.3	39.1	39.9	39.9	39.9	39.8	39.8
	Fuel oil C	$355	MJ/l	42.7	42.2	42.0	42.0	42.2	42.0	42.1	42.5	42.9
	Fuel oil B	$356	MJ/l	40.2	40.2	40.4	40.4	40.4	40.4	40.4	40.4	40.4
	Fuel oil C for general use	$357	MJ/l	42.7	42.2	42.0	42.0	42.2	42.0	42.1	42.5	42.9
	Fuel oil C for power generation	$358	MJ/l	41.1	41.1	41.3	41.2	41.2	41.2	41.3	41.2	41.2
	Lubricating oil	$365	MJ/l	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2	40.2
	Asphalt	$371	MJ/kg	41.6	41.2	40.9	41.0	41.1	41.0	41.0	41.4	41.9
	Non asphalt heavy oil products	$372	MJ/kg	41.6	41.2	40.9	41.0	41.1	41.0	41.0	41.4	41.9
	Oil coke	$375	MJ/kg	35.6	35.6	35.6	29.9	29.9	29.9	29.9	29.9	29.9
	Galvanic furnace gas	$376	MJ/m^{3}N	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4	8.4
	Refinary gas	$380	MJ/m^{3}N	39.3	39.3	44.9	44.9	44.9	44.9	44.9	44.9	44.9
	Liquefied petroleum gas	$390	MJ/kg	50.2	50.2	50.2	50.8	50.8	50.8	50.8	50.8	50.8
Natural Gas	Liquefied natural gas	$410	MJ/kg	54.6	54.6	54.6	54.6	54.6	54.6	54.6	54.7	54.7
	Indigenous natural gas	$420	MJ/m^{3}N	42.1	42.4	42.6	42.9	44.7	44.8	44.7	44.7	44.8
	Indigenous natural gas	$421	MJ/m^{3}N	42.1	42.4	42.6	42.9	44.7	44.8	44.7	44.7	44.8
	Coal mining gas	$422	MJ/m^{3}N	36.0	36.0	16.7	16.7	16.7	16.7	16.7	16.7	16.7
	Off-gas from crude oil	$423	MJ/m^{3}N	42.1	42.4	42.6	42.9	44.7	44.8	44.7	44.7	44.8
Town Gas	Town gas	$450	MJ/m^{3}N	41.9	41.9	41.1	44.8	44.8	44.8	44.8	44.8	44.8
	Town gas	$460	MJ/m^{3}N	41.9	41.9	41.1	44.8	44.8	44.8	44.8	44.8	44.8
	Small-scale town gas	$470	MJ/m^{3}N	100.5	100.5	100.5	100.5	100.5	100.5	100.5	100.5	100.5

c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The Carbon-Hydrogen ratio of hydrocarbons is strongly correlated with the calorific value in theory, Therefore, the standard deviations of the sample data of each fuel's calorific value are used for uncertainty assessment of emission factors based on the assumption that the deviation of the carbon content and that of the calorific value are equal. The uncertainty of energy consumption in TJ given in the *General Energy Statistics* was assessed based on the given statistical error of solid fuels, liquid fuels, and gaseous fuels. As a result, the uncertainty was determined to be 1% for CO_2 emissions from fuel combustion. A summary of uncertainty assessment methods is provided in Annex 7.

● ***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） *Source-specific QA/QC and Verification*

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） *Source-specific Recalculations*

The CO_2 emissions in FY2010 and FY2011 were recalculated with a revision of the fuel consumption for FY2010 and FY 2011 in the *General Energy Statistics*.

The CO_2 emissions from Biomass fuels in FY2005-2009 were recalculated as some errors were corrected.

Updating the amount of municipal and industrial waste, the CO_2 emissions from Other fuels for the period FY2007-2011 were recalculated. For details of waste incineration, see Section 8.4. of Chapter 8.

f） *Source-specific Planned Improvements*

Over 20 years have passed since the investigation was implemented for *The Report on Estimation of CO_2 Emissions in Japan* (Environment Agency), which had been used as a data source of carbon emission factors of fuels. Later, the consideration of the development of revised carbon emission factors for each fuel by direct measurement of the carbon content and calorific value has been started with the cooperation of the Agency of Natural Resources and Energy. Until now, the preliminary research was executed for the research design, where the fuel type, measuring item and measurement method, which are necessary to be measured in the future research, are studied. From now on, the establishment of carbon emission factor based on the research and its result will be studied, and the revised carbon emission factor is planned to be applied to the inventory immediately after the completion of the study.

3.2.2. CH_4 and N_2O Emissions from Energy Industry (1.A.1.:CH_4, N_2O)

a) Source/Sink 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 in the 800–900°C range. N_2O can also be generated when NO_X makes contact with catalysts for NO_X removal.

Contribution of CH_4 and N_2O emissions from this category to the total GHG emissions are small in Japan. The N_2O emission from fluidized bed boilers are relatively large in this category. The N_2O emission from fluidized bed boilers contribute to the increase of GHG emission 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.

b) Methodological Issues

- ***Estimation Method***

Because it is possible to use fuel-specific, sector-specific and furnace-specific activity data, and also to set country-specific emission factors, CH_4 and N_2O emissions from fuel combustion in this category are calculated by using Tier 2 country-specific emission factors in accordance with the *1996 Revised IPCC Guidelines* and the *GPG (2000)*.

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

- ***Emission Factors***

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 3-9 were employed based on data obtained from surveys conducted in Japan (

Table 3-10) to establish emission factors for each kind of facility using the following combustion calculation formula.

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

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 (%)

Table 3-9 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 for 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 3-10 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, Revised 1996 IPCC Guidelines (Reference Manual), 1997

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 3-11, Table 3-12). Anomalous values were excluded according to t-testing or expert judgment when calculating the average values. Please refer to the Annex 3.1 for the actual measurement data to establish the emission factors.

Table 3-11 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)	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	NA	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 Steam Coal	$135													
	Underground	$136													
	Open Pit	$137													
	Hard Coal, Anthracite & Lignite	$140													
Coal Products	Coke	$161	0.13	31	1.7	NA	NA	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	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	Slack Gasoline	$271	0.26	31	1.7	0.43	0.16	NA	1.5	29	6.6	0.83	0.81	0.70	54
	Slack Kerosene	$272													
	Slack Diesel Oil or Gas Oil	$273													
	Slack Fuel Oil	$274	0.10												
	Cracked Gasoline	$275	0.26												
	Cracked Diesel Oil or Gas Oil	$276													
	Feedstock Oil for Refinery and Mixing	$277													
	Naphtha	$281													
	Reformed Material Oil	$282													
	Gasoline	$310													
	Premium Gasoline	$311													
	Regular Gasoline	$312													
	Jet Fuel	$320													
	Kerosene	$330													
	Gas Oil or Diesel Oil	$340													
	Fuel Oil A	$351													
	Fuel Oil C	$355	0.10												
	Heating Oil B	$356													
	Heating Oil C	$357													
	Heating Oil C for Power Generation	$358													
	Lublicating Oil	$365	0.26												
	Asphalt	$371	0.13			NA	NA	0.054				13	NA	NA	NA
	Non Asphalt Heavy Oil Products	$372													
	Oil 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	1.7	0.43	0.16	NA	1.5	29	6.6	2.3	0.81	0.70	54
	Indigenous Natural Gas	$420													
	Indigenous Natura l Gas	$421													
	Coal Mining Gas	$422													
	Off-gas from Crude Oil	$423													
Town Gas	Town Gas	$450	0.23	31	1.7	0.43	0.16	NA	1.5	29	6.6	2.3	0.81	0.70	54
	Town Gas	$460													
	Small Scale Town Gas	$470													
Biomass	Biomass Energy	$N130	29	29	29	29	29	29	29	29	29	29	29	29	29
	Biomass Power Generation	$N131													
	Biomass Thermal Use	$N132													
	Thermal Use of Black Liquor	$N522	4.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Thermal Use of Wasted Woods	$N523	29	29	29	29	29	29	29	29	29	29	29	29	29
	Charcoal	-	75	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 3-12 N_2O emission factors for different fuels and furnaces (unit: kg-N_2O/TJ)

	Fuel	Code	Boilers: Boiler (other than fluidized-bed boiler)	Boilers: Normal pressure fluidized-bed boiler	Boilers: Pressurized fluidized-bed boiler	Industrial furnaces: Blast furnace	Industrial furnaces: Petroleum and gas furnaces	Industrial furnaces: Catalytic regenerator	Industrial furnaces: Coke oven	Industrial furnaces: Other industrial furnace	Internal-combustion engines: Gas turbine	Internal-combustion engines: Diesel engine	Internal-combustion engines: Gas engine, petrol engine
Coal	Steel Making Coal	$110											
	Coking Coal	$111			0.85								
	PCI Coal	$112											
	Imported Steam Coal	$130											
	Imported Coal: for general use	$131	0.85	54		NA	NA	NA	NA	1.1	NA	NA	NA
	Imported Coal: for power generation	$132			5.2								
	Indigenous Steam Coal	$135											
	Underground	$136											
	Open Pit	$137											
	Hard Coal, Anthracite & Lignite	$140			0.85								
Coal Products	Coke	$161											
	Coal Tar	$162	0.85	54	0.85	NA	NA	7.3	NA	1.1	NA	NA	NA
	Coal Briquette	$163											
	Coke Oven Gas	$171											
	Blast Furnace Gas	$172	0.17	0.17	0.17	0.047	0.21	NA	0.14	1.2	0.58	2.2	0.85
	Converter Furnace Gas	$175				NA							
Oil	Crude Oil for Refinery	$210											
	Crude Oil for Power Generation	$220	0.22	0.22	0.22	NA	0.21	NA	NA	1.8	0.58	2.2	0.85
	Bituminous Mixture Fuel	$221											
	Natural Gas Liquid & Condensate	$230											
Oil Products	Slack Gasoline	$271											
	Slack Kerosene	$272	0.19	0.19	0.19								
	Slack Diesel Oil or Gas Oil	$273											
	Slack Fuel Oil	$274	0.22	0.22	0.22								
	Cracked Gasoline	$275											
	Cracked Diesel Oil or Gas Oil	$276											
	Feedstock Oil for Refinery and Mixing	$277											
	Naphtha	$281											
	Reformed Material Oil	$282											
	Gasoline	$310	0.19	0.19	0.19								
	Premium Gasoline	$311					0.21	NA	NA	1.8	0.58	2.2	0.85
	Regular Gasoline	$312											
	Jet Fuel	$320											
	Kerosene	$330				NA							
	Gas Oil or Diesel Oil	$340											
	Fuel Oil A	$351											
	Fuel Oil C	$355											
	Heating Oil B	$356	0.22	0.22	0.22								
	Heating Oil C	$357											
	Heating Oil C for Power Generation	$358											
	Lublicating Oil	$365	0.19	0.19	0.19								
	Asphalt	$371											
	Non Asphalt Heavy Oil Products	$372	0.85	54	0.85		NA	7.3		1.1	NA	NA	NA
	Oil Coke	$375											
	Galvanic Furnace Gas	$376											
	Refinary Gas	$380	0.17	0.17	0.17		0.21	NA	0.14	1.2	0.58	2.2	0.85
	Liquified Petroleum Gas	$390							NA				
Natural Gas	Liquefied Natural Gas	$410							NA				
	Indigenous Natural Gas	$420											
	Indigenous Natura l Gas	$421	0.17	0.17	0.17	NA	0.21	NA	0.14	1.2	0.58	2.2	0.85
	Coal Mining Gas	$422											
	Off-gas from Crude Oil	$423											
Town Gas	Town Gas	$450											
	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 Town Gas	$470											
Biomass	Biomass Energy	$N130											
	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 Thermal Use	$N132											
	Thermal Use of Black Liquor	$N522	4.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Thermal Use of Wasted Woods	$N523	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
	Charcoal		75	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

- ***Activity Data***

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, and 2008. 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 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 *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]

4) The fuel-specific, furnace-specific, and sector-specific fuel consumption in the *General Survey of*

the Emissions of Air Pollutants is used as activity data for the consumption of fuels (such as charcoal) not included in the *General Energy Statistics*, and furnaces for which the fuel consumption data of the *General Energy Statistics* cannot be used (in specific terms, carbon fuels of catalytic regenerators).

➢ *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.

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties for emission factors were evaluated on the basis of applied statistical procedures, expert judgment, and default data for each energy type. The uncertainties of activity data were estimated by using the standard deviation and the percentage of data collection indicated in the *General Survey of the Emissions of Air Pollutants.* The uncertainties for emissions from fuel combustion were estimated to be 47% for CH_4 emissions and 33% for N_2O emissions. A summary of uncertainty assessment methods is provided in Annex 7.

● ***Time-series Consistency***

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.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

CH_4 and N_2O emissions in FY2010-2011 were recalculated with a revision of the fuel consumption for FY2010-2011 in the *General Energy Statistics*.

CH_4 and N_2O emissions for FY1990-2007 were recalculated, as some errors were corrected.

Updating the amount of incinerated waste, the emissions from Other fuels for the period FY2010-2011 were recalculated. For details of waste incineration, see Section 8.4. of Chapter 8.

f) Source-specific Planned Improvements

There are no major planned improvements in this source category.

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

a) Source/Sink 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); and other (1.A.2.f).

In FY2012, CO_2 emissions from this category accounted for 333,095 Gg-CO_2, and represented 24.8% of Japan's total GHG emissions (excluding LULUCF). As for breakdown of GHG emissions within the manufacturing industries and construction category in FY2012, iron and steel (1.A.2.a) accounts for 45.0%, and is followed by other (1.A.2.f.) (30.6%), chemicals (1.A.2.c) (15.0%), pulp, paper and print (1.A.2.d) (6.3%), food processing, beverages and tobacco (1.A.2.e) (2.5%) and non-ferrous metals (1.A.2.b) (0.6%).

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.

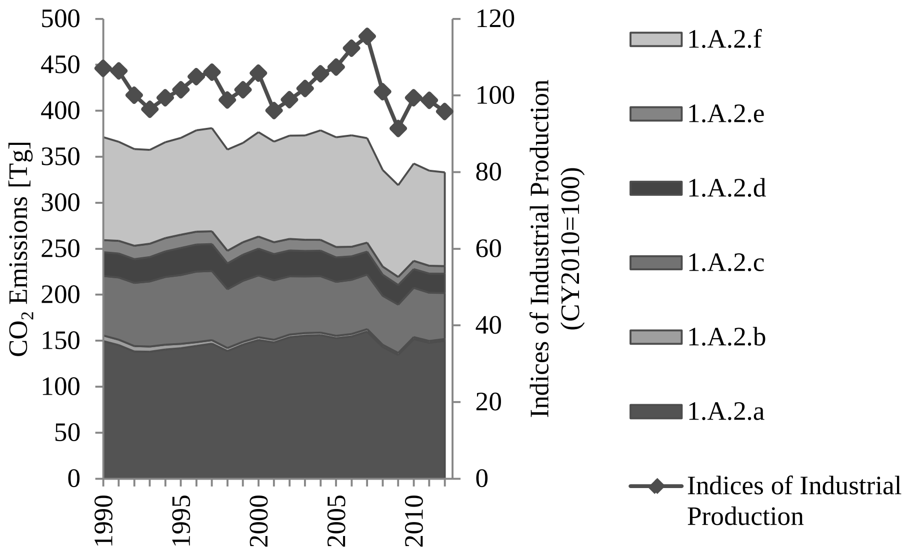

Figure 3-4 The trends of CO_2 emissions from Manufacturing Industries and Construction category (1.A.2) and related indicator

b) Methodological Issues

● ***Estimation Method***

See Section 3.2.1 b) (1.A.1).

- ***Emission Factors***

See Section 3.2.1 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 industry (1.A.1).

Table 3-13 Energy consumptions in Manufacturing Industries and Construction category (1.A.2) (unit: PJ)

Fuel	1990	1995	2000	2005	2008	2009	2010	2011	2012
Liquid Fuels	2,140	2,265	2,226	1,942	1,516	1,469	1,471	1,459	1,368
Solid Fuels	2,289	2,179	2,245	2,321	2,213	2,066	2,297	2,209	2,264
Gaseous Fuels	156	236	257	373	428	432	458	486	473
Biomass	194	193	198	203	202	186	277	263	253
Other Fuels	63	75	89	153	173	173	178	181	169
Total	4,842	4,948	5,015	4,992	4,532	4,326	4,681	4,598	4,527

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 #6xxx[5]), energy consumption related to non-utility power generation for use in one's own factories and offices (non-utility power generation #22xx), and energy consumption related to steam production for use in own factories and offices (industrial steam #23xx) 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 use #95xx-#98xx), this amount was subtracted.

The non-utility power generation and industrial steam generation sectors are included in the energy conversion sector in *General Energy Statistics*. However, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* 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 provided in 1.A.2.

The IEF of CO_2 emissions from liquid fuels in 1.A.2.f (Other) decreased between 1997 and 1998, and increased between 1998 and 1999 because of revisions made to the statistics on the manufacturing sector. The manufacturing sector data in Japan's Energy Balance Table (*General Energy Statistics*), the activity data, are based on the Ministry of Economy, Trade and Industry's *Yearbook of the Current Survey of Energy Consumption.* The subjects to be surveyed to obtain the data for the *Yearbook of the Current Survey of Energy Consumption* were changed in December, 1997. The survey for the industries of dyeing, rubber product and non-ferrous metal product has been discontinued since 1998. Also, since 1998, business institutions or designated items to be surveyed for the industries of chemicals, cement & ceramics, glass wares, iron and steel, non-ferrous metals and machinery have been changed. For these reasons the IEF of CO_2 emissions from liquid fuels in 1.A.2.f (Other) has changed. The details are documented and described in Annex 2 (A2.2).

Table 3-14 shows the correspondence between the sectors of Japan's Energy Balance Table and those of the CRF (1.A.2).

[5] x indicates any number.

Table 3-14 Correspondence between sectors of Japan's Energy Balance Table and of the CRF (1.A.2)

CRF			Japan's Energy Balance Table	
1A2		Manufacturing industries and construction		
	1A2a	Iron and steel	Auto, iron & steel	#2217
			Steam generation, iron & steel	#2307
			Final energy consumption, iron & steel	#6580
			Non-energy, iron & steel	#9680
	1A2b	Non-ferrous metals	Auto, non-ferrous metal	#2218
			Steam generation, non-ferrous metal	#2308
			Final energy consumption, non-ferrous metal	#6590
			Non-energy, non-ferrous metal	#9690
	1A2c	Chemicals	Auto, chemical textiles	#2212
			Steam generation, chemical textiles	#2302
			Final energy consumption, chemical textiles	#6530
			Non-energy, chemical textiles	#9630
			Auto, chemical	#2214
			Steam generation, chemical	#2304
			Final energy consumption, chemical	#6550
			Non-energy, chemical	#9650
	1A2d	Pulp, paper and print	Auto, pulp & paper	#2211
			Steam generation, pulp & paper	#2301
			Final energy consumption, pulp & paper	#6520
			Non-energy, pulp & paper	#9620
	1A2e	Food processing, beverages and tobacco	Final energy consumption, food	#6510
			Non-energy, non-manufacturing industry (food)	#9610
	1A2f	Other		
		Mining	Final energy consumption, mining	#6120
			Non-energy, non-manufacturing industry (mining)	#9610
		Construction	Final energy consumption, construction	#6150
			Non-energy, non-manufacturing industry (construction)	#9610
		Oil products	Auto, oil products	#2213
			Steam generation, oil products	#2303
			Final energy consumption, oil products	#6540
			Non-energy, oil products	#9640
		Glass wares	Auto, glass wares	#2215
			Steam generation, glass wares	#2305
			Final energy consumption, glass wares	#6560
			Non-energy, glass wares	#9660
		Cement & ceramics	Auto, cement & ceramics	#2216
			Steam generation, cement & ceramics	#2306
			Final energy consumption, cement & ceramics	#6570
			Non-energy, cement & ceramics	#9670
		Machinery	Auto, machinery & others	#2219
			Steam generation, machinery & others	#2309
			Final energy consumption, machinery	#6600
			Non-energy, machinery	#9700
		Duplication adjustment	Auto, duplication adjustment	#2220
			Steam generation, duplication adjustment	#2310
			Final energy consumption, duplication adjustment	#6700
			Non-energy, duplication adjustment	#9710
		Other industries & small and medium enterprises	Auto, others	#2250
			Final energy consumption, other industries & small and medium	#6900
			Non-energy, other industries & small and medium enterprises	#9720

- Auto: Non-utility power generation
- #95xx-#98xx items are subtracted as non-energy use activities.

c）Uncertainties and Time-series Consistency

See Section 3.2.1 c).

d）Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e）Source-specific Recalculations

The CO_2 emissions for the period FY2009-FY2011 were recalculated with a revision of the fuel consumption in for the period FY2009-FY2011 in the *General Energy Statistics*.

The CO_2 emissions from Biomass fuels in FY1990-2010 were recalculated as some errors were corrected.

Updating the amount of waste used as raw material or fuel, the emission estimates for the period FY2006-2007 and 2010-2011 were recalculated. For details of waste incineration, see Section 8.4. of Chapter 8.

f）Source-specific Planned Improvements

See Section 3.2.1 f)

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

a）Source/Sink 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); and other (1.A.2.f).

b）Methodological Issues

- ***Estimation Method***

See Section 3.2.2 b) (1.A.1).

- ***Emission Factors***

See Section 3.2.2 b) (1.A.1).

- ***Activity Data***

See Section 3.2.2 b) (1.A.1).

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

c) *Uncertainties and Time-series Consistency*

See Section 3.2.2 c).

d) *Source-specific QA/QC and Verification*

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e) *Source-specific Recalculations*

CH_4 and N_2O emissions in FY2008-2011 were recalculated with a revision of the fuel consumption in FY2008-2011 in the *General Energy Statistics*.

N_2O emissions for the period FY2011 were recalculated with a correction of activity data of normal pressure fluidized-bed boiler in a certain plant.

CH_4 and N_2O emissions for the period FY1990-2007 were recalculated, as some errors were corrected.

Updating the amount of waste used as raw material or fuel, the emissions from Other fuels for FY2007 and FY2011 were recalculated. For details of waste incineration, see Section 8.4. of Chapter 8.

f) *Source-specific Planned Improvements*

There are no major planned improvements in this source category.

3.2.5. CO_2 Emissions from Transport (Mobile Combustion) (1.A.3.:CO_2)

a) *Source/Sink 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), and navigation (1.A.3.d).

In 2012, CO_2 emissions from this category accounted for 217,309 Gg-CO_2, and represented 16.2% of Japan’s total GHG emissions (excluding LULUCF). As for breakdown of GHG emissions within the Transport (Mobile Combustion) category in FY2012, road transportation (1.A.3.b) accounts for 90.4%, and is followed by navigation (1.A.3.d) (5.0%), civil aviation (1.A.3.a) (4.4%), and railways (1.A.3.c) (0.3%).

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.

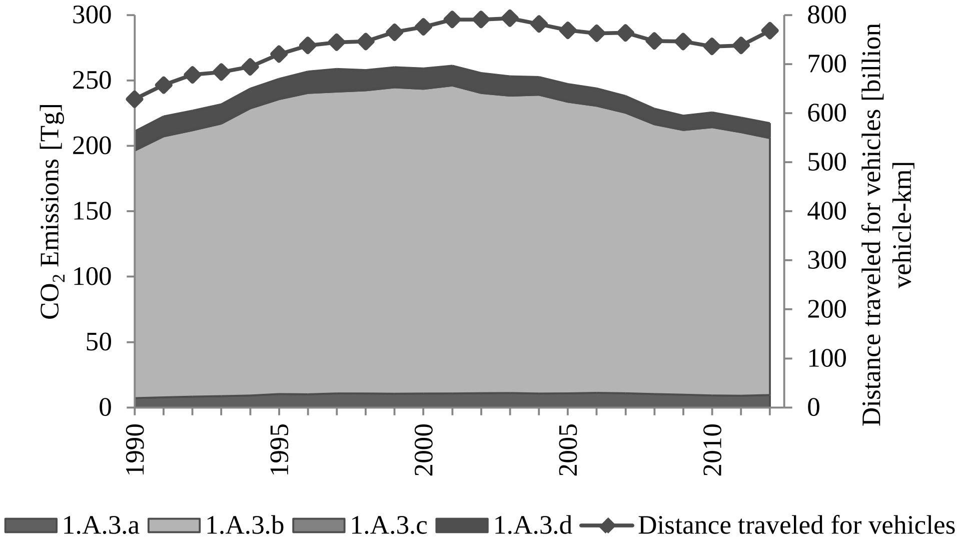

Figure 3-5 The trends of CO_2 emissions from Transport (Mobile Combustion) (1.A.3.) and related indicator

b） Methodological Issues

- ***Estimation Method***

See Section 3.2.1 b).

- ***Emission Factors***

See Section 3.2.1 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 2 (A2.3).

- ***Activity Data***

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

Table 3-15 Energy consumptions in Transport (Mobile Combustion) (1.A.3.) (unit: PJ)

Fuel	1990	1995	2000	2005	2008	2009	2010	2011	2012
Liquid Fuels	3,116	3,706	3,827	3,653	3,375	3,298	3,334	3,275	3,213
Solid Fuels	0.033	0.031	0.046	0.037	0.038	0.044	0.043	0.043	0.043
Gaseous Fuels	0.0033	0.14	1.14	3.97	4.92	4.80	4.67	4.59	4.33
Biomass	NO	NO	NO	NO	NO	NO	NO	NO	NO
Other Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	3,116	3,707	3,828	3,657	3,380	3,302	3,339	3,280	3,217

The values subtracting final energy consumption reported under ‘non-energy’ [#9850] from energy consumption reported under ‘civil aviation’ [#8140] [#8540], ‘road transportation’ [#8110] [#8510] [#8115] [#8190] [#8590], ‘railways’ [#8120] [#8520] and ‘navigation’ [#8130] [#8530] in Japan’s Energy Balance Table (*General Energy Statistics*) are used for activity data. Because energy consumption reported under ‘non-energy’ was used for purposes other than combustion and was considered not emitting CO_2, these values were deducted. (see Table 3-16)

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

CRF			Japan's Energy Balance Table	
1A3		Transport		
	1A3a	Civil aviation	Final energy consumption, passenger air	#8140
			Final energy consumption, freight air	#8540
			Non-energy, transportation (air)	#9850
	1A3b	Road transportation	Final energy consumption, passenger car	#8110
			Final energy consumption, freight, freight truck & lorry	#8510
			Final energy consumption, passenger bus	#8115
			Final energy consumption, passenger, transportation fraction estimation error	#8190
			Final energy consumption, freight, transportation fraction estimation error	#8590
			Non-energy, transportation (car, truck & lorry, bus)	#9850
	1A3c	Railways	Final energy consumption, passenger rail	#8120
			Final energy consumption, freight rail	#8520
			Non-energy, transportation (rail)	#9850
	1A3d	Navigation	Final energy consumption, passenger ship	#8130
			Final energy consumption, freight ship	#8530
			Non-energy, transportation (ship)	#9850
	1A3e	Other transportation	-	-

- #95xx-#98xx items are subtracted as non-energy use activities.

c） *Uncertainties and Time-series Consistency*

See Section 3.2.1 c).

d） *Source-specific QA/QC and Verification*

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） *Source-specific Recalculations*

The emissions for the period FY2009-FY2011 were recalculated with the revision of the fuel consumption in this category described in the *General Energy Statistics* for the period FY2009-FY2011.

Because the natural gas fuel consumption by natural gas-powered vehicle has been little and there was no such consumption statistics, also the CO_2 emissions from natural gas-powered vehicles were included in the commercial/institutional section of other sectors (1.A.4), the CO_2 emissions from this source were reported as "IE" here until FY2009. Similarly, the coal consumption by steam locomotives is little and there is no such consumption statistics, also the CO_2 emissions from steam locomotive are included in the commercial/institutional section of other sectors (1.A.4), the CO_2 emissions from this source are reported as "IE" here. In response to the review, the activity data from FY1990 has become to be estimated on the *General Energy Statistics*, therefore the emissions after GHG Inventory submitted in 2014 are reported as the gaseous fuels and solid fuels in this category. Along with such new data, the emissions from gaseous fuels from FY1990 to FY2009, and the emissions from solid fuels from FY1990 to FY2011 were recalculated.

f） Source-specific Planned Improvements

There are no major planned improvements in this source category.

3.2.6. CH_4 and N_2O Emissions from Transport (Mobile Combustion) (1.A.3.:CH_4 , N_2O)

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

3.2.6.1. Civil Aviation (1.A.3.a.)

a） Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from energy consumption in civil 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 emission.

b） Methodological Issues

● ***Estimation Method***

Emissions have been calculated using the Tier 2a method for jet fuel and the Tier 1 for aviation gasoline, in accordance with the decision tree of the *GPG (2000)* (Page 2.58, Fig. 2.7).

CH_4 and N_2O emissions associated with landing and take-off (LTO) of domestic airliners using jet fuel = Emission factor per LTO 1 cycle per domestic airliner × Number of LTO cycles of aircraft on domestic routes

LTO: Landing and take-off

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

CH_4 and N_2O emission 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 *Revised 1996 IPCC Guidelines* are used for emission factors for CH_4 and N_2O for LTO. The values used for emission factors for CH_4 and N_2O for cruising were calculated by converting the default values given in the *Revised 1996 IPCC Guidelines* into kg-CH_4/l using the specific gravity of jet fuel (0.78 t/kl) given in survey by the Petroleum Association of Japan. (See Table 3-17)

➢ *Aviation gasoline*

The default values given in the *Revised 1996 IPCC Guidelines* are used for emission factors for CH_4 and N_2O (see Table 3-17).

Table 3-17 CH_4 and N_2O emission factors for aircraft

		CH_4	N_2O
Jet aircraft (Jet fuel)	During take-off and landing	0.3 [kg-CH_4/LTO]	0.1 [kg-N_2O/LTO]
	During cruise	0 [kg-CH_4/kl]	0.078 [kg-N_2O/kl]
Other than jet aircraft (Aviation gasoline)	-	0.06 [g-CH_4/MJ]	0.0009 [g-N_2O/MJ]

LTO: Landing and take-off

Source: Ministry of the Environment, *Results of Review of Greenhouse Gases Emissions Estimations Part 3* (August 2002). *Revised 1996 IPCC Guidelines*, Volume 3, Table 1-47

● ***Activity Data***

➢ *Jet fuel*

The number of take-offs and landings given in the *Statistical Yearbook of Air Transport* of the Ministry of Land, Infrastructure, Transport and Tourism is used as activity data for take-off and landing. The fuel consumption for take-off and landing was calculated by multiplying the fuel consumption for one takeoff or landing given in the *IPCC Guidelines*, by the number of takeoffs and landings given above.

The fuel consumption for cruising was estimated by subtracting the amount of jet fuel consumed at take-off and landing, from the total jet fuel consumption calculated from the *Statistical Yearbook of Air Transport* of the Ministry of Land, Infrastructure, Transport and Tourism.

➢ *Aviation gasoline*

The consumption of gasoline in the civil aviation taken from the *General Energy Statistics* of the Agency for Natural Resources and Energy was used for activity data.

Table 3-18 Activity data used for emission estimates of aircraft

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of LTO cycle	LTO	430,654	532,279	667,559	715,767	726,415	716,804	714,671	728,194	778,363
Jet fuel comsumption of cruise	kl	2,330,514	3,223,547	3,537,205	3,543,856	3,334,851	3,146,174	2,923,113	2,829,543	2,985,803
Gasoline comsumption	kl	5,345	6,029	4,287	7,662	2,773	2,358	1,882	1,660	1,907

c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* were applied (200% for CH_4 and 10,000% for N_2O). The uncertainty of activity data was 10%; determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 200% for CH_4 and 10,000% for N_2O. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

For the emission factors the same values have been used since FY1990. The activity data for jet fuel from the *Statistical Yearbook of Air Transport* and aviation gasoline from the *General Energy Statistics* have been used consistently since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

No recalculation was performed.

f） Source-specific Planned Improvements

No improvements are planned.

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

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

Table 3-19 Reporting categories and definitions of emissions from automobiles

Vehicle type	Definition	Fuel type for emission reporting			
		Gasoline	Diesel	LPG	LNG
Light passenger vehicle	Light vehicle used for transportation of people.	Yes	-	-	-
Light cargo truck	Light vehicle used for transportation of cargo	Yes	-	-	-
Passenger vehicle	Regular passenger vehicle or small vehicle used for transportation of people, with a capacity of 10 persons or less.	Yes	Yes	Yes	-
Bus	Regular passenger vehicle or small vehicle used for transportation of people, with a capacity of 11 persons or more.	Yes	Yes	-	-
Small cargo truck	Small vehicle used for transportation of cargo.	Yes	Yes	-	-
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	-	-
NPG vehicle	Any of the above vehicles that use natural gas as fuel.	-	-	-	Yes
Motorcycle	Two-wheeled vehicle	Yes	-	-	-

Different estimation methods are used for the categories of light passenger vehicles, light cargo trucks, passenger vehicles, buses, small cargo trucks, regular cargo trucks, and special-purpose vehicles (3.2.4.2.a), natural gas-powered vehicles (3.2.4.2.b), and motorcycles (3.2.4.2.c). Thus, they are described in the following sections.

3.2.6.2.a. Light Passenger Vehicles, Light Cargo Trucks, Passenger Vehicles, Buses, Small Cargo Trucks, Regular Cargo Trucks, and Special-purpose Vehicles

a） Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from 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 have been calculated by multiplying the distance traveled per vehicle type by the emission factors using the Tier 3 method, in accordance with the decision tree of the *GPG (2000)* (Page 2.45, Fig. 2.5).

● ***Emission Factors***

The emission factors for CH_4 and N_2O have been established for each type of fuel for each vehicle type, using the data shown in Table 3-20. "JAMA data" means that the raw emission factors of Japan Automobile Manufacturers Association are arranged as combined mode emission factors[6] by car registration year. The emission factors are estimated by multiplying the arranged emission factors of JAMA by the number of vehicles per car registration year of each car type (see Table 3-21, Table 3-22). "Measured data" means that the emission factors are based on actual Japanese data. The emission factors were weighted averages of actual Japanese data estimated per each class of running speed, by the proportion of distance traveled per 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 motor vehicles in Japan because the proportion of distance traveled by each class of running speed during congestion was applied. "1996GL" and "GPG (2000)" mean that the emission factors were established using the default values in the IPCC Guidelines.

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

Table 3-20 Data source of the emission factors of vehicle

Vehicle type	Gasoline engine		Diesel engine	
	CH_4	N_2O	CH_4	N_2O
Light passenger vehicle	JAMA data	JAMA data		
Light cargo truck	JAMA data	JAMA data		
Passenger vehicle	JAMA data	JAMA data	JAMA data	JAMA data
Bus	1996GL	GPG(2000) +	Measured data	1996GL
Small cargo truck	JAMA data	JAMA data	JAMA data	JAMA data
Regular cargo truck	1996GL	GPG(2000) +	JAMA data	JAMA data
Special-purpose vehicle	1996GL	GPG(2000) +	Measured data	1996GL

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

6 The JAMA data were provided by test mode. The emission factors were calculated using mainly "combined driving mode". "Combined driving mode" = "10.15 driving mode" ×0.88 + "11 driving mode" ×0.12. "10.15 driving mode" is a hot start driving mode and "11 driving mode" is a cold start driving mode.

3) 1996GL: Using the default values in the *Revised 1996 IPCC Guidelines*.

4) GPG (2000)+ : Calculated by using default data given in the *GPG (2000)* in consideration of the fuel consumption by car type indicated in the *Statistical Yearbook of Motor Vehicle Transport* and the calorific values indicated in the *General Energy Statistics*.

Table 3-21 CH_4 emission factors for road transportation

Fuel	Vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light passenger vehicle	g-CH_4/km	0.008	0.008	0.008	0.007	0.006	0.005	0.005	0.005	0.005
	Passenger vehicle (including LPG)	g-CH_4/km	0.015	0.015	0.014	0.011	0.009	0.009	0.008	0.007	0.007
	Light cargo truck	g-CH_4/km	0.019	0.019	0.018	0.012	0.008	0.008	0.007	0.007	0.006
	Small cargo truck	g-CH_4/km	0.021	0.021	0.021	0.015	0.011	0.010	0.010	0.009	0.008
	Regular cargo truck	g-CH_4/km	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
	Bus	g-CH_4/km	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
	Special-purpose vehicle	g-CH_4/km	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
Diesel	Passenger vehicle	g-CH_4/km	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.014
	Small cargo truck	g-CH_4/km	0.010	0.011	0.010	0.009	0.009	0.009	0.008	0.008	0.008
	Regular cargo truck	g-CH_4/km	0.017	0.016	0.015	0.014	0.013	0.012	0.012	0.011	0.011
	Bus	g-CH_4/km	0.019	0.018	0.017	0.017	0.017	0.017	0.017	0.017	0.017
	Special-purpose vehicle	g-CH_4/km	0.017	0.015	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Table 3-22 N_2O emission factors for road transportation

Fuel	Vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light passenger vehicle	g-N_2O/km	0.014	0.014	0.014	0.009	0.007	0.006	0.005	0.005	0.004
	Passenger vehicle (including LPG)	g-N_2O/km	0.024	0.024	0.020	0.012	0.008	0.007	0.006	0.006	0.005
	Light cargo truck	g-N_2O/km	0.024	0.024	0.022	0.013	0.009	0.008	0.007	0.007	0.006
	Small cargo truck	g-N_2O/km	0.021	0.022	0.022	0.013	0.009	0.008	0.008	0.007	0.006
	Regular cargo truck	g-N_2O/km	0.039	0.041	0.038	0.037	0.035	0.035	0.036	0.036	0.036
	Bus	g-N_2O/km	0.045	0.046	0.044	0.041	0.042	0.040	0.040	0.040	0.040
	Special-purpose vehicle	g-N_2O/km	0.039	0.042	0.037	0.031	0.030	0.028	0.028	0.028	0.028
Diesel	Passenger vehicle	g-N_2O/km	0.006	0.005	0.004	0.004	0.005	0.005	0.005	0.005	0.006
	Small cargo truck	g-N_2O/km	0.009	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012
	Regular cargo truck	g-N_2O/km	0.015	0.015	0.015	0.017	0.028	0.030	0.032	0.033	0.035
	Bus	g-N_2O/km	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
	Special-purpose vehicle	g-N_2O/km	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

● ***Activity Data***

The estimates of annual distance traveled by each vehicle type and by each fuel type have been used as activity data. The method of estimating activity data was to multiply the proportion of distance traveled for each fuel type, which was 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*.

Table 3-23 Distance traveled per vehicle type

Fuel	Vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light passenger vehicle	10^6 vehicle-km	15,281	39,386	70,055	102,601	121,327	128,585	128,756	131,574	146,330
	Passenger vehicle	10^6 vehicle-km	289,697	323,022	363,991	372,663	351,943	355,499	352,902	359,394	376,019
	Light cargo truck	10^6 vehicle-km	85,336	84,534	74,914	73,789	73,312	72,382	70,097	68,131	72,255
	Small cargo truck	10^6 vehicle-km	36,981	25,892	24,988	26,597	26,345	26,054	26,427	26,961	27,685
	Regular cargo truck	10^6 vehicle-km	447	361	331	741	1,059	1,088	1,083	1,122	1,196
	Bus	10^6 vehicle-km	95	32	21	46	73	85	97	95	107
	Special-purpose vehicle	10^6 vehicle-km	827	851	1,584	1,556	1,726	1,822	1,754	1,660	1,763
Diesel	Passenger vehicle	10^6 vehicle-km	42,252	66,787	58,832	30,902	17,692	14,879	13,993	13,837	13,061
	Small cargo truck	10^6 vehicle-km	55,428	62,032	57,221	41,674	36,295	33,281	30,697	30,630	31,376
	Regular cargo truck	10^6 vehicle-km	66,434	78,086	82,693	78,866	77,887	74,146	71,859	68,064	61,255
	Bus	10^6 vehicle-km	7,016	6,736	6,598	6,605	6,503	6,464	6,346	6,116	6,169
	Special-purpose vehicle	10^6 vehicle-km	10,420	15,373	19,115	18,869	19,851	19,361	19,245	18,524	19,157
LPG	Passenger Vehicle	10^6 vehicle-km	18,368	17,192	15,382	13,971	12,864	12,362	12,599	11,628	11,332

● ***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***

➢ *Biomass fuels*

Currently, since very little ethanol fuel exists in Japan, there are very few ethanol-powered vehicles. For that reason, the emissions of CH_4 and N_2O associated with the use of vehicles using biomass as fuel have been reported as “NO”.

➢ *Other (Methanol)*

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

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors for the CH_4 and N_2O emissions from all types of vehicles (excluding natural gas-powered vehicles and motorcycles), the default values given in the *GPG (2000)* (40% for CH_4 and 50% for N_2O) were applied. For the uncertainty of activity data, 50% was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods was applied. As a result, the uncertainties of the emissions were determined to be 64% for CH_4 and 71% for N_2O. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

The emission factors were developed by using the same method since FY1990. The activity data have been estimated using the data in the *Statistical Yearbook of Motor Vehicle Transport,* by a consistent estimation method from FY1990 onward.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

CH_4 and N_2O emissions from FY1990 to FY2011 were recalculated due to the updates and the improvement of the actual measurements data for emission factor of gasoline and LPG vehicles. CH_4 and N_2O emissions from FY1994 to FY2011 were recalculated due to the updates of the actual measurements data for emission factors of diesel passenger vehicle and diesel regular truck.

The car-mileage data of each vehicle type had been transferred to the *Survey on Motor Vehicle Fuel Consumption* and continuity adjustment with previous data was done, thus CH_4 and N_2O emissions from FY2010 to FY2011 were recalculated.

f） Source-specific Planned Improvements

For some types of vehicles, it is necessary to consider whether more suitable emission factors, representing Japan's circumstances should be established on the basis of actual measurements, because currently the default values presented in the *Revised 1996 IPCC Guidelines* and *GPG (2000)* are used.

3.2.6.2.b. Natural gas-powered vehicles

a） Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from natural gas-powered vehicles.

b） Methodological Issues

● ***Estimation Method***

The emissions were calculated by multiplying the distance traveled per type of natural gas-powered vehicles by the emission factor for that vehicle type.

● ***Emission Factors***

The CH_4 emission factors for natural gas-powered passenger vehicles, buses, and trucks were determined using JAMA data and the same method was used as for the same type of gasoline or diesel powered vehicles.

The N_2O emission factors for trucks were determined using the emission factors established for each travel speed category based on actual measurements taken in Japan, and weighted by the percentage of distance traveled for each travel speed category reported in the *Road Transport Census* (Ministry of

Land, Infrastructure, Transport and Tourism).

However, N_2O emission factors for passenger vehicle, buses, and special-purpose vehicles, and CH_4 emission factors for special-purpose vehicles were determined by the method indicated in Table 3-24 in the absence of actual measurement data in Japan.

Table 3-24 CH_4 and N_2O emission factors for natural gas-powered vehicles

Vehicle Type	Calculation method for emission factor		Average emission factor	
	CH_4	N_2O	CH_4 [g-CH_4/km]	N_2O [g-N_2O/km]
Passenger vehicle	JAMA data	Used the emission factor for truck, taking the specification of the vehicle type into account.	0.013	0.0002
Bus	JAMA data	Determined from the emission factor for truck which was adjusted by the ratio of equivalent inertia weight, taking vehicle weight into consideration.	0.050	0.0384
Truck	JAMA data	Determined based on actual measurements	0.082	0.0128
Special-purpose vehicle	Determined from the percentage of distance traveled per travel speed category which was adjusted by the emission factor per travel speed category for trucks, taking travel patterns of natural gas-powered special-purpose vehicles into consideration.		0.093	0.0145

● ***Activity Data***

The annual distance traveled per vehicle type was 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 was taken from the number of introduction of natural gas-powered vehicles per type in the data compiled by the Japan Gas Association, from FY1997, the number of registered natural gas-powered vehicles reported in the *Various Number of Motor Vehicle* compiled by the Automobile Inspection and Registration Information Association (AIRIA). For the annual distance traveled per vehicle, the activity data ware calculated using the annual total distance traveled by natural gas-powered vehicles, reported in the *Statistical Yearbook of Motor Vehicle Fuel Consumption* compiled by the Ministry of Land, Infrastructure, Transport and Tourism, the annual distance traveled per vehicle type reported in the *Statistical Yearbook of Motor Vehicle Transport* and the number of registered vehicle per vehicle type reported in the *Statistics of AIRIA Number of Motor Vehicle* compiled by the AIRIA.

Table 3-25 Annual distance traveled by natural gas-powered vehicles per vehicle type

vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Passenger vehicle	1,000 vehicle-km	54	104	2,043	6,270	7,299	7,301	6,401	5,340	4,383
Bus	1,000 vehicle-km	0	1,856	15,132	48,026	57,072	56,272	52,391	49,048	46,599
Truck	1,000 vehicle-km	205	9,127	74,516	238,612	297,707	289,637	285,443	285,990	265,800
Special-purpose vehicle	1,000 vehicle-km	62	2,755	22,495	72,031	89,870	87,434	84,317	83,666	84,279

c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The uncertainty of emission factors for both CH_4 and N_2O were determined as 1000% by expert judgment. The uncertainty of activity data was 50%; determined as a standard value by the 2002 Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties of the emissions were determined to be 1001% for both CH_4 and N_2O. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

The same emission factors were used for all years. The activity data were estimated based on the number of registered vehicles reported in the *Various 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 is not popular. As for other activity data, the data were estimated based on the *Statistical Yearbook of Motor Vehicle Transport* and the *Statistics of AIRIA Number of Motor Vehicle* by the same estimation method consistently since FY1990 until the nearest year.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

The emissions from FY1990 to FY2011 were recalculated due to the accuracy improvement of the activity data. The improvement included the revision of the number of natural gas powered vehicles by using the number of registered vehicle instead of the total number of vehicle previously introduced in which the discarded vehicle was not taken into account.

f） Source-specific Planned Improvements

To set more precise emission factors that better reflect the actual conditions, it is necessary to stock much more data on the annual distance traveled per vehicle type and to improve the estimation methods used.

3.2.6.2.c. Motorcycles

a） Source/Sink Category Description

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

b） Methodological Issues

- ***Estimation Method***

The country-specific estimation method of THC (Total Hydro Carbon) emissions from motorcycles, which are sources not required to report under the PRTR[7] System, was developed by the Ministry of the Environment. The CH_4 and N_2O emissions from motorcycles are estimated based on that method. The emissions were calculated for two emission sources, “Hot start” and “Increment at cold start”, using the equations below. For details of the calculation method, see the *Greenhouse Gases Estimation Methods Committee Report – Transportation* (February, 2006).

CH_4 and N_2O emissions from hot-start of motorcycles = Emission factor for vehicle-km per type of motorcycle × Total annual distance traveled by motorcycles per type

[7] Pollutant Release and Transfer Register

<u>CH_4 emissions from increment at cold start of motorcycles</u>
= Emission factor per start per type × Number of engine start-ups per year by each type of motorcycle

- ***Emission Factors***

➢ *Hot start*

The THC emission factor for hot starts, derived from actual measurement data in Japan, was multiplied by the ratio of the CH_4 emission factor to the THC emission factor. The THC emission factors for motorcycles were established for each vehicle type, stroke, and unregulated/regulated status. Accordingly, the emission factor per travel speed was determined for each type of motorcycle by apportioning the number of motorcycles in operation to these categories based on the estimated component ratio. For N_2O, the default emission factor for *US motorcycles/European motorcycles* given in the *Revised 1996 IPCC Guidelines* (0.002 [g-N_2O/km]) is used for unregulated status and JAMA data are used for regulated status (Integrated EFs are estimated from the ratio of each number of motorcycles for unregulated/regulated status).

➢ *Increment at cold start*

The emission factor was determined for each type of motorcycle by multiplying the THC emission factor for cold-start increment, derived from actual measurement data in Japan, by the CH_4/THC ratio for hot start, and apportioning the results based on the ownership component ratio. No emission factor was set for N_2O because the increment at cold start for N_2O was assumed to be included in the default emission factor for hot start.

Table 3-26 CH_4 and N_2O emission factors for motorcycles

Emission source	Vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Two-wheel vehicle (hot start, CH_4)	Small motor vehicle, type 1	g-CH_4/km	0.124	0.118	0.101	0.067	0.043	0.038	0.034	0.029	0.026
	Small motor vehicle, type 2	g-CH_4/km	0.088	0.090	0.083	0.051	0.032	0.028	0.024	0.022	0.020
	Light two-wheel vehicle	g-CH_4/km	0.155	0.159	0.137	0.070	0.045	0.040	0.035	0.031	0.027
	Small two-wheel vehicle	g-CH_4/km	0.117	0.119	0.112	0.070	0.046	0.042	0.036	0.032	0.029
Two-wheel vehicle (cold start, CH_4)	Small motor vehicle, type 1	g-CH_4/startup	0.039	0.039	0.034	0.023	0.019	0.019	0.018	0.018	0.017
	Small motor vehicle, type 2	g-CH4/startup	0.012	0.012	0.013	0.016	0.018	0.018	0.018	0.018	0.018
	Light two-wheel vehicle	g-CH4/startup	0.016	0.016	0.018	0.024	0.026	0.026	0.026	0.027	0.027
	Small two-wheel vehicle	g-CH4/startup	0.043	0.043	0.042	0.035	0.032	0.032	0.031	0.031	0.030
Two-wheel vehicle (hot start, N_2O)	Small motor vehicle, type 1	g-N_2O/km	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Small motor vehicle, type 2	g-N_2O/km	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Light two-wheel vehicle	g-N_2O/km	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	Small two-wheel vehicle	g-N_2O/km	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001

- ***Activity Data***

➢ *Hot start*

Based on the motorcycle operation data in the *Road Transport Census*, the annual distance traveled was determined for each type of motorcycle and travel speed category using the ratio of total distance traveled per type, obtained from sources including the *Survey of Motorcycle Market Trends* and the ratio of distance traveled per travel speed category, estimated from the *Road Transport Census*. In determining the activity data for this source, the reduction rate of motorcycle operation due to rain or snow as well as increases in the ownership and the distance traveled during the years outside the survey were taken into consideration.

➢ *Increment at cold start:*

The annual number of engine startups (times/year) per type of motorcycle was determined by the following formula:

<u>Number of engine startups</u>
= (Expected operation of new motorcycle in number of days in year)$_{type}$
× (Operation factor)$_{elapsed\ years}$ × (Reduction rate of operation due to rain and snow)$_{prefecture}$
× (Average number of startups per day)$_{type}$ × (Number of motorcycles owned)$_{type,\ prefecture,\ elapsed\ years}$

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (40% for CH_4 and 50% for N_2O) were applied. The uncertainty of activity data was 50%; this was determined as a standard value by the 2002 Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties of the emissions were determined to be 64% for CH_4 and 71% for N_2O. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

The same estimation methods were used since FY1990. The activity data were estimated using the data in the *Statistical Yearbook of Motor Vehicle Transport* by a consistent estimation method since FY1990.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e) Source-specific Recalculations

The CH_4 and N_2O emissions from FY2009 to FY2011 were recalculated due to the updates of the reduction rate of motorcycle operation due to rain or snow which is used for activity data calculation, and the CH_4 emissions from FY2007 to FY2011 were recalculated due to the improvement of the actual measurements data used for emission factor of regulated motorcycles.

f) Source-specific Planned Improvements

No improvements are planned.

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

a) Source/Sink 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 and locomotives that use diesel oil. In addition, there are small amounts of emissions from coal-fired steam locomotives.

b) Methodological Issues

- ***Estimation Method***

The emissions were calculated by multiplying the emission factor by fuel consumption on a calorific basis. The *GPG (2000)* does not provide a decision tree for a calculation method for this source.

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

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

● ***Emission Factors***

For emission factors for diesel-powered railway cars, the default values shown in the *Revised 1996 IPCC Guidelines* under *Diesel engines – Railways* were 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 shown in the *Revised 1996 IPCC Guidelines* under *Coal – Railways* were used after conversion to a per-weight value using the calorific value of imported steam coal.

Table 3-27 Default values for railway emission factors

	Diesel engines	Steam locomotives
CH_4	0.004 [g-CH_4/MJ]	10 [kg-CH_4/TJ]
N_2O	0.03 [g-N_2O/MJ]	1.4 [kg-N_2O/TJ]

Source: *Revised 1996 IPCC Guidelines*, Vol. 3, p. 1.91, Table 1-49; p. 1.35, Table 1-7; and p. 1.36, Table 1-8

● ***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 sector shown in the *General Energy Statistics* compiled by the Agency for National Resources and Energy was used as activity data, respectively.

Table 3-28 Activity data used for estimation of emissions from railways

Fuel type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Diesel oil	kl	356,224	313,235	269,711	248,211	230,381	224,972	217,955	211,255	211,255
Coal	kt	1.3	1.2	1.7	1.4	1.5	1.7	1.7	1.7	1.7

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties for emission factors were determined to be 5.0% for CH_4 and 5.0% for N_2O in accordance with the Committee for the Greenhouse Gas Emission Estimation Methods. For the uncertainty of activity data of diesel-engine locomotives, 10% given in the *Statistical Yearbook of Railway Transport*, which is the original statistics of the *General Energy Statistics*, was applied. The activity data of coal-fired steam locomotives are derived from multiplying distance traveled of coal-fired steam locomotives shown in the *Statistical Yearbook of Railway Transport* by fuel consumption per distance traveled. For the uncertainty of activity data of coal-fired steam locomotives, 11.2% aggregated by the values given in the *Statistical Yearbook of Railway Transport* and the fuel consumption per distance traveled, was applied. As a result, the uncertainties of the emissions were determined to be 11.2% for CH_4 and N_2O from diesel-engine locomotives and 12.2% for CH_4 and N_2O from coal-fired steam locomotives. The overall uncertainty of the emissions from Railways (1.A.3.c) were determined to be 10.3% for CH_4 and 11.2% for N_2O. The uncertainty assessment

methods are summarized in Annex 7.

- ***Time-series Consistency***

The same emission factors were used since FY1990. The data given in the *General Energy Statistics* were used as activity data consistently since FY1990.

d） *Source-specific QA/QC and Verification*

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e） *Source-specific Recalculations*

Since the consumption data of the coal has become to be estimated on the *General Energy Statistics*, the GHG emissions from FY1990 to FY2011 were recalculated with the revision of the coal consumption data for all years from FY1990.

f） *Source-specific Planned Improvements*

For the emission factor for diesel engine-railways, discussions are needed whether more suitable emission factors (i.e., those that better reflect Japan's circumstances) should be established on the basis of actual measurements, because currently the default values presented in the *Revised 1996 IPCC Guidelines* and *GPG (2000)* are used.

3.2.6.4. Navigation (1.A.3.d.)

a） *Source/Sink Category Description*

This section provides the estimation methods for CH_4 and N_2O emissions from navigation. Ships emit CH_4 and N_2O through the use of diesel oil and fuel oils A, B and C during their navigation.

b） *Methodological Issues*

- ***Estimation Method***

The emissions were calculated using the default values for CH_4 and N_2O given in the *Revised 1996 IPCC Guidelines*, in accordance with the decision tree of the *GPG (2000)* (Page 2.52, Fig. 2.6).

> *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 *Revised 1996 IPCC Guidelines* (see the following table) were converted to emission factors per liter using the calorific value for each type of fuel (diesel oil, fuel oil A, B and C).

Table 3-29 Default emission factors for navigation

	Value
CH_4	0.007 [g-CH_4/MJ]
N_2O	0.002 [g-N_2O/MJ]

Source: *Revised 1996 IPCC Guidelines* Vol. 3, page 1.90, Table 1-48

- ***Activity Data***

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

Table 3-30 Activity data used for estimation of emissions from ships

Fuel type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Diesel oil	1,000 kl	133	208	204	195	189	163	154	149	149
Fuel oil A	1,000 kl	1,602	1,625	1,728	1,324	1,046	946	1,007	969	968
Fuel oil B	1,000 kl	526	215	152	63	25	20	18	16	15
Fuel oil C	1,000 kl	2,446	3,002	3,055	2,873	2,592	2,420	2,482	2,460	2,521

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (200% for CH_4 and 1,000% for N_2O) were applied. The uncertainty of activity data was 13%. This was a precision value (95% confidence interval) provided in the *Statistical Yearbook of Coastwise Vessel Transport* that was an original statistic of the *General Energy Statistics*. As a result, the uncertainties of the emissions were determined to be 200% for CH_4 and 1,000% for N_2O. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

The same values for emission factors were used since FY1990. The activity data given in the *General Energy Statistics* were used as activity data for navigation consistently since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. The Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

The CH_4 and N_2O emissions in FY2011 were recalculated with the revision of the fuel consumption described in the *General Energy Statistics* in FY2011.

f） Source-specific Planned Improvements

For the emission factor for navigation, discussions are needed to set more suitable factors (i.e., those that better reflect Japan's circumstances) that are based on actual measurements, because currently the default values presented in the *Revised 1996 IPCC Guidelines* are used.

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

a） Source/Sink 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/fisheries (1.A.4.c) sectors.

In FY2012, CO_2 emissions from this category accounted for 160,902 Gg-CO_2, and represented 12.0%

of Japan's total GHG emissions (excluding LULUCF). As for breakdown of GHG emissions within the "Other sectors" category in FY2012, commercial/institutional (1.A.4.a) accounts for 56.8%, and is followed by residential (1.A.4.b) (36.2%) and agriculture/forestry/fisheries (1.A.4.c) (6.9%).

CO_2 emissions from this category change due to activity level of commercial/institutional, number of households 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. In the middle of 2000s, the CO_2 emissions were decreased while the ITA increased, that implies that the energy source are shifting from liquid fuels to electricity and gaseous fuels, whose emission factors are relatively low.

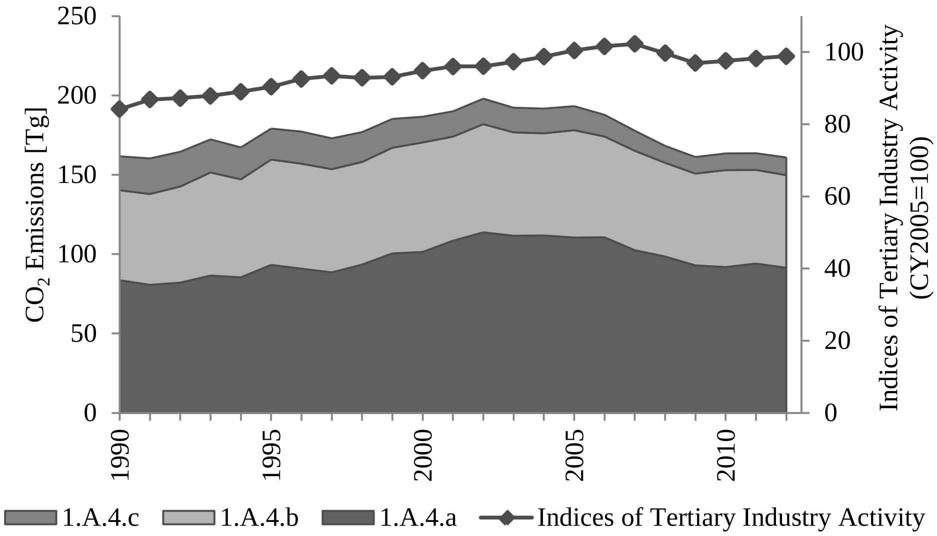

Figure 3-6 The trends of CO_2 emissions from Other Sectors (1.A.4) and related indicator

b) Methodological Issues

● Estimation Method

See Section 3.2.1 b).

● Emission Factors

See Section 3.2.1 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 for the energy industry (1.A.1).

The activity data for each sub-category are the values for the final energy consumption in the commercial/institutional (#7500), residential (#7100), and agriculture/forestry/fisheries (#6110) sectors in the *General Energy Statistics*. Because the energy consumption above includes the amount of non-energy use which was used for purposes other than combustion, these values were deducted from the energy consumption in each category.

Table 3-31 Energy consumptions in Other Sectors (1.A.4) (unit: PJ)

Fuel	1990	1995	2000	2005	2008	2009	2010	2011	2012
Liquid Fuels	2,053	2,242	2,216	2,144	1,659	1,563	1,531	1,527	1,505
Solid Fuels	56	34	34	25	23	23	23	22	22
Gaseous Fuels	397	536	721	955	1,117	1,107	1,186	1,198	1,187
Biomass	4.44	3.18	2.01	0.99	0.96	0.88	1.00	0.94	0.76
Other Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total	2,510	2,815	2,973	3,125	2,799	2,693	2,740	2,749	2,715

Table 3-32 Correspondence between sectors of Japan's Energy Balance Table and those of the CRF (1.A.4)

CRF			Japan's Energy Balance Table	
1A4		Other sectors		
	1A4a	Commercial/institutional	Final energy consumption, commercial & others	#7500
			Non-energy, residential, commercial & others (commercial & others)	#9800
	1A4b	Residential	Final energy consumption, residential	#7100
			Non-energy, residential, commercial & others (residential)	#9800
	1A4c	Agriculture/forestry/fisheries	Final energy consumption, agriculture, forestry & fishery	#6110
			Non-energy, non-manufacturing industry (agriculture, forestry & fishery)	#9610

- #95xx-#98xx items are not energy use activities.

c) Uncertainties and Time-series Consistency

See Section 3.2.1 c).

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e) Source-specific Recalculations

The GHG emissions in FY1990-2011 were recalculated due to the revision of the fuel consumption in FY1990-2011 in the *General Energy Statistics*.

f) Source-specific Planned Improvements

There are no major planned improvements in this source category.

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

a) Source/Sink 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/fisheries (1.A.4.c) sectors.

b) Methodological Issues

- ***Estimation Method***

See Section 3.2.2 b) (1.A.1).

● ***Emission Factors***

See Section 3.2.2 b) (1.A.1) about commercial/institutional (1.A.4.a) and agriculture/forestry/fisheries (1.A.4.c).

Since furnace-specific activity data is not available, the default values given in the *Revised 1996 IPCC Guidelines* were used for the emission factors of residential (1.A.4.b).

Table 3-33 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
Household equipment	Solid fuel	290	IPCC default value converted to the higher heating value
Household equipment	Gaseous fuel	4.5	IPCC default value converted to the higher heating value
Household equipment	Biomass fuel	290	IPCC default value converted to the higher heating value

Table 3-34 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
Household equipment	Solid fuel	1.3	IPCC default value converted to the higher heating value
Household equipment	Gaseous fuel	0.090	IPCC default value converted to the higher heating value
Household equipment	Biomass fuel	3.8	IPCC default value converted to the higher heating value

● ***Activity Data***

See Section 3.2.2 b) (1.A.1).

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

c） Uncertainties and Time-series Consistency

See Section 3.2.1 c).

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

The GHG emissions in FY1990-2011 were recalculated with a revision of the fuel consumption in FY1990-2011 in the *General Energy Statistics*.

f） *Source-specific Planned Improvements*

There are no major planned improvements in this source category.

3.2.9. Comparison of Sectoral and Reference Approaches

The information such as comparison of CO_2 emissions and analysis of difference between two approaches is documented and described in Annex 4.

3.2.10. International Bunker Fuels

a） *Source/Sink 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 exclusion of emissions from bunker fuels used for international navigation and aviation from the national totals has been reported as the memo item.

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 3.2.1).

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 *Revised 1996 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, Japan considers that it is in line with the GPG (2000) to adopt the country-specific EF for jet kerosene from the following viewpoint and this country-specific EF is appropriate value, which is compared to the default value and other countries' value:

- According to Figure 2.2 in the GPG (2000), country-specific value should be used when there is not a significant difference (approximately more than 2%) between obtained and default value. The difference between the Japanese EF) and the default value is only 1.2%;
- According to section 2.1.1.6 in the GPG (2000), the uncertainty of EF is likely to be less than 5%. The difference between the Japanese EF and the default value is inside the range;
- 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 also inside the range

- CO_2 EF is higher than that used by other reporting Parties including Greece, Portugal, Turkey and the United Kingdom of Great Britain and Northern Ireland in GHG inventories submitted in 2013 (FCCC/WEB/SAI/2013).

【CH_4, N_2O】

The default values given in the *Revised 1996 IPCC Guidelines* are used for CH_4 and N_2O emission factors.

Table 3-35 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	0.002 [g-CH_4/MJ] [a]	0.1 [kg-N_2O/t] [b]
Shipping	Fuel oil A, fuel oil B, fuel oil C, diesel oil, kerosene	0.007 [g-CH_4/MJ] [c]	0.002 [g-N_2O/MJ] [c]

a. Revised 1996 IPCC Guidelines Vol. 3, Table 1-47

b. Revised 1996 IPCC Guidelines Vol. 3, Table 1-52

c. Revised 1996 IPCC Guidelines Vol. 3, Table 1-48

● ***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.

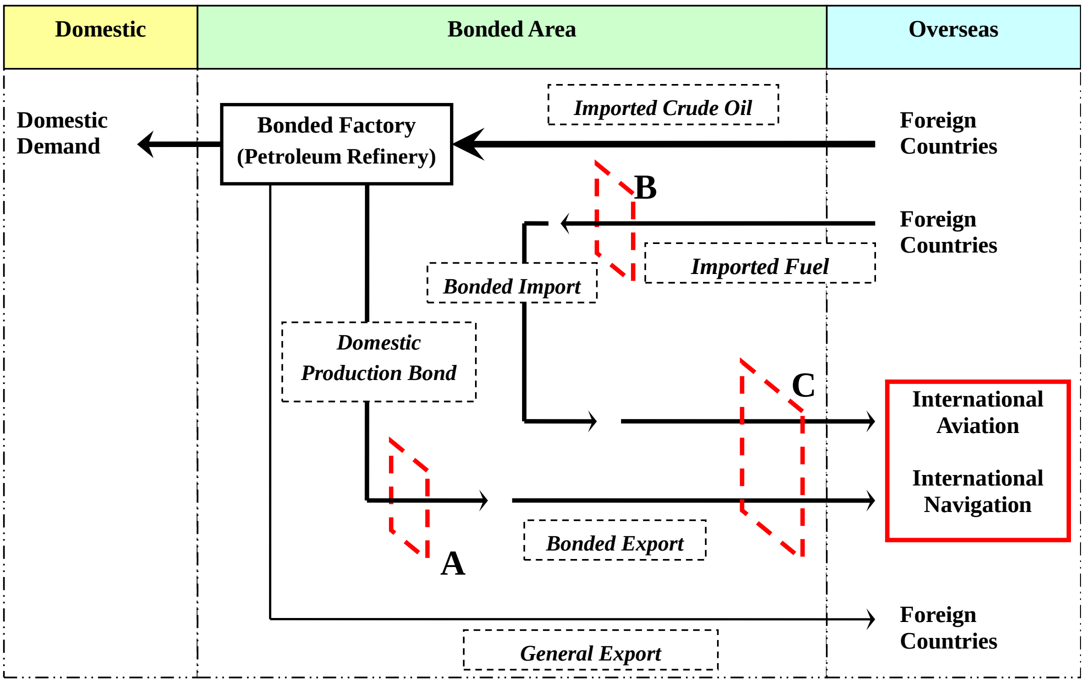

Figure 3-7 Activity data for international bunkers

It is assumed that jet fuel is used by aircraft, while fuel oil A, B, C, diesel oil and kerosene 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).

【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 standard calorific values given in the *General Energy Statistics* by the Agency for Natural Resources and Energy.

【CH_4, N_2O】

The *Revised 1996 IPCC Guidelines* provide a default emission factor that is 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 of 0.95, except for 0.975 for fuel oil C.

In addition, regarding activity data of N_2O from international aviation, the *Revised 1996 IPCC Guidelines* provide a default emission factor in weight units. In order to adapt the activity data to this unit, the kiloliter-based consumption data is multiplied by the density of jet fuel given in survey by the Petroleum Association of Japan (0.78 [g/cm^3]) for N_2O from aircraft.

Glossary

<u>Bonded Jet Fuel</u>

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 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 voyages 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 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.

3.2.11. 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 use (#9500) which is used as feedstocks without the combustion and oxidation process was deducted from the total energy consumption in the *General Energy Statistics*, because these amounts of fuel were used as feedstocks without the combustion and oxidation process.

The consumption in this category includes the followings: (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.)

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

Table 3-36 Allocated CO_2 emissions from fuel used for non-energy purpose such as feedstock

CO_2 emitting process	IPCC Category	Type of fuel used for non-energy purpose such as feedstock	Emission factor	Calorific value (FY2005)
Ammonia production	2.B.1	Naphtha	18.17 [t-C/TJ]	33.6 [MJ/l]
		Liquefied petroleum gas (LPG), (until FY2002)	16.13 [t-C/TJ]	50.8 [MJ/kg]
		Petroleum-derived gas (off-gas)	14.15 [t-C/TJ]	44.9 [MJ/m^3]
		Natural gas	13.90 [t-C/TJ]	43.5 [MJ/m^3]
		Coal (thermal coal, imports)	24.71 [t-C/TJ]	25.7 [MJ/kg]
		Oil coke (petroleum coke)	25.35 [t-C/TJ]	29.9 [MJ/kg]
		Liquefied natural gas (LNG)	13.47 [t-C/TJ]	54.6 [MJ/kg]
		Coke oven gas (COG) (until FY2001)	10.99 [t-C/TJ]	21.1 [MJ/m^3]
Silicon carbide production	2.B.4	Oil coke	2.3 [t-CO_2/t] (per oil coke consumption amount)	
Calcium carbide production	2.B.4	Oil coke	From reducing agent in production: 1.09 [t-CO_2/t] (confidential information after FY2008), from use: 1.10 [t-CO_2/t] (both EFs per calcium carbide production amount)	
Ethylene production	2.B.5	Naphtha	Confidential information	
Use of electric arc furnaces in steel production	2.C.1	Oil coke	Estimated from carbon electrodes consumption amount	
Waste incineration	6.C	Lubricant, paraffin, naphtha, LPG, etc.	Industrial waste oil: 2,919 [kg-CO2/t (wet)], industrial waste plastic: 2,554 [kg-CO2/t (wet)], municipal waste plastic: 2,726 [kg-CO2/t (dry)] (all EFs per waste amount burned)	
Emissions from the decomposition of petroleum-derived surfactants	6.D	Naphtha, etc.	Synthetic alcohol: 2,839 [kg-CO2/t], alkyl benzene: 3,220 [kg-CO2/t], alkyl phenol: 3,000 [kg-CO2/t], ethylene oxide: 2,000 [kg-CO2/t], (all EFs per surfactant decomposition amount)	

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 sector (2.B and 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 3-37.

Table 3-37 Reported category of CO_2 emissions from iron and steel and non-ferrous metals process

CO_2 emitting process	IPCC Category	Type of fuel used for non-energy purpose such as feedstock	Reported category in Energy Sector
Coke production	2.B.5, 2.C.1	Coal	1.A.1.c (Manufacture of solid fuels and other energy industries)
Iron and steel production, Pig iron production, Sinter production	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)

3.2.12. CO_2 capture from flue gases and subsequent CO_2 storage

The amount of CO_2 capture from flue gases and subsequent CO_2 storage is not estimated in Japan.

3.2.13. 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 (6.C) in accordance with the *1996 Revised IPCC Guidelines*. The value of emissions is included in fuel combustion (1.A.1 and 1.A.2) in accordance with the *1996 Revised IPCC Guidelines* and the *GPG (2000)*. Please refer to Chapter 8 for the details of the estimation methods.

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

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 industry (category 1.A.1)" or "manufacturing/construction (1.A.2)" according to the use of waste as fuels. The fuel type is classified as "other fuels".

Table 3-38 Categories for the calculation of emissions from waste incineration with energy recovery

Incineration	Waste category	Estimation classification		Category to be allocated to	CO_2	CH_4	N_2O
Waste incineration with energy recovery	Municipal solid waste	Plastics	Fossil-fuel derived plastics	1.A.1	○	○[b]	○[b]
			Biomass-based plastics (biogenic)		NA		
		Textiles	Synthetic textile		○		
			Natural fiber (biogenic)		NA		
		Other (biogenic)			NA		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil		○	○	○
			Animal and vegetable oil (biogenic)		NA		
		Plastics	Fossil-fuel derived plastics		○	○	○
			Biomass-based plastics (biogenic)		NA		
		Food waste [Animal and vegetable residues/animal carcasses (biogenic)]			NA	○	○
		Paper/ cardboard (biogenic)			NA	○	○
		Wood (biogenic)			NA	○	○
		Textile	Synthetic textile		IE[c]	IE[c]	IE[c]
			Natural fiber (biogenic)		NA	○	○
		Sludge	Sewage sludge (biogenic)		NO	NO	NO
			Other than sewage sludge (biogenic)		NA	○	○
	Specially controlled industrial waste				IE[d]	IE[d]	IE[d]
Direct use of waste as fuel	Municipal solid waste	Plastics	Fossil-fuel derived plastics	1.A.1/2	○	○	○
			Biomass-based plastics (biogenic)		NA		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil	1.A.2	○	○	○
			Animal and vegetable oil (biogenic)		NA		
		Plastics	Fossil-fuel derived plastics	1.A.2	○	○	○
			Biomass-based plastics (biogenic)		NA		
		Wood (biogenic)		1.A.2	NA	○	○
	Waste tire	Fossil origin		1.A.1/2	○	○	○
		Biogenic origin			NA		
Use of waste processed as fuel	Refuse derived fuel (RDF, RPF)	Fossil origin		1.A.1/2	○	○	○
		Biogenic origin			NA		

Note:

a) 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 *Revised 1996 IPCC Guidelines*; instead it is estimated as a reference value and reported under " Biogenic" in Table 6.A,C of the CRF.

b) Estimated in bulk.

c) Included in fossil-fuel derived plastics in ISW.

d) Included in "Specially controlled industrial waste" incineration without energy recovery.

e) ○: Emissions reported.

The greenhouse gas emissions from waste incineration for energy purpose and with energy recovery are shown in Table 3-39.

Table 3-39 GHG emissions from waste incineration with energy recovery and use of waste as raw material or fuel

Gas	Item			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	1.A.1 Energy industries	a. Public electricity and heat production		Gg-CO_2	6,493	7,080	9,075	7,965	7,333	6,392	5,934	6,232	6,456
		b. Petroleum refining		Gg-CO_2	NO	NO	0.6	6.4	3.5	4.6	5.7	4.6	5.5
		c. Manufacture of solid fuels and other energy industries		Gg-CO_2	NO	NO	15	239	192	204	240	230	232
	1.A.2. Manufacturing industries and construction	a. Iron and steel		Gg-CO_2	NO	NO	308	634	377	443	552	522	568
		b. Non-ferrous metals		Gg-CO_2	118	63	51	17	3.3	1.6	1.7	1.6	NO
		c. Chemicals		Gg-CO_2	14	64	89	66	66	67	72	71	82
		d. Pulp, paper and print		Gg-CO_2	NO	55	113	993	1,606	1,654	1,719	1,745	1,763
		e. Food processing, beverages and tobacco		Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
		f. Other	Mining	Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Construction	Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Oil products	Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Glass wares	Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Cement & ceramics	Gg-CO_2	597	1,122	1,876	2,317	2,467	2,428	2,539	2,522	2,499
			Machinery	Gg-CO_2	41	26	20	10	NO	NO	NO	NO	NO
			Duplication adjustment	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
			Other industries & small & medium enterprises	Gg-CO_2	1,854	2,092	1,595	2,877	2,556	2,367	2,448	2,483	2,406
	Total			Gg-CO_2	9,116	10,503	13,142	15,124	14,603	13,561	13,511	13,811	14,012
CH_4	1.A.1 Energy industries	a. Public electricity and heat production		Gg-CH_4	0.54	0.54	0.60	0.15	0.15	0.13	0.13	0.13	0.13
		b. Petroleum refining		Gg-CH_4	NO	NO	0.000002	0.000018	0.000010	0.000013	0.000016	0.000013	0.000015
		c. Manufacture of solid fuels and other energy industries		Gg-CH_4	NO	NO	IE	IE	IE	IE	IE	IE	IE
	1.A.2. Manufacturing industries and construction	a. Iron and steel		Gg-CH_4	NO	NO	NA	0.00036	0.00065	0.00065	0.00066	0.00061	0.00061
		b. Non-ferrous metals		Gg-CH_4	0.00032	0.00018	0.00014	0.000077	0.000015	0.000008	0.000008	0.000008	NO
		c. Chemicals		Gg-CH_4	0.00006	0.00013	0.00019	0.00019	0.00019	0.00019	0.00020	0.00020	0.00023
		d. Pulp, paper and print		Gg-CH_4	NO	0.0001	0.0002	0.0027	0.0045	0.0046	0.0048	0.0048	0.0049
		e. Food processing, beverages and tobacco		Gg-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE
		f. Other	Mining	Gg-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Construction	Gg-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Oil products	Gg-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Glass wares	Gg-CH_4	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Cement & ceramics	Gg-CH_4	0.036	0.084	0.15	0.21	0.25	0.24	0.22	0.22	0.22
			Machinery	Gg-CH_4	0.00018	0.00012	0.000091	0.000046	NO	NO	NO	NO	NO
			Duplication adjustment	Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
			Other industries & small & medium enterprises	Gg-CH_4	1.77	1.77	2.22	2.90	4.02	4.23	4.21	4.38	3.55
	Total			Gg-CH_4	2.34	2.39	2.98	3.26	4.41	4.60	4.57	4.74	3.90
				Gg-CO_2 eq.	49.20	50.28	62.52	68.53	92.70	96.69	95.90	99.58	81.91
N_2O	1.A.1 Energy industries	a. Public electricity and heat production		Gg-N_2O	1.20	1.33	1.56	1.14	1.04	0.96	0.94	0.92	0.95
		b. Petroleum refining		Gg-N_2O	NO	NO	0.00001	0.00012	0.00006	0.00008	0.00010	0.00008	0.00010
		c. Manufacture of solid fuels and other energy industries		Gg-N_2O	NO	NO	IE	IE	IE	IE	IE	IE	IE
	1.A.2. Manufacturing industries and construction	a. Iron and steel		Gg-N_2O	NO	NO	NA	0.0007	0.0013	0.0013	0.0013	0.0012	0.0012
		b. Non-ferrous metals		Gg-N_2O	0.00024	0.00013	0.00011	0.00006	0.00001	0.00001	0.00001	0.00001	NO
		c. Chemicals		Gg-N_2O	0.00004	0.00060	0.00092	0.00107	0.00110	0.00113	0.00121	0.00121	0.00140
		d. Pulp, paper and print		Gg-N_2O	NO	0.00066	0.0014	0.0175	0.0279	0.0287	0.0297	0.0303	0.0307
		e. Food processing, beverages and tobacco		Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
		f. Other	Mining	Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Construction	Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Oil products	Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Glass wares	Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
			Cement & ceramics	Gg-N_2O	0.014	0.025	0.040	0.052	0.052	0.051	0.055	0.054	0.054
			Machinery	Gg-N_2O	0.00013	0.000085	0.000066	0.000033	NO	NO	NO	NO	NO
			Duplication adjustment	Gg-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
			Other industries & small & medium enterprises	Gg-N_2O	0.027	0.028	0.033	0.047	0.058	0.060	0.060	0.062	0.052
	Total			Gg-N_2O	1.24	1.38	1.63	1.26	1.18	1.10	1.09	1.07	1.09
				Gg-CO_2 eq.	385.39	428.89	506.38	391.21	364.87	340.85	336.98	332.35	337.33

3.3. Fugitive Emissions from Fuels (1.B.)

The Fugitive Emissions subsector consists of intentional and unintentional emissions of CO_2, CH_4, and N_2O from unburned fossil fuels during their mining, production, processing, refining, transportation, storage, and distribution.

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.

In 2012, GHG emissions from fugitive emissions from fuels were 397 Gg-CO_2 eq. and accounted for 0.03 % of Japan's total GHG emissions (excluding LULUCF). The emissions have decreased by 89 % compared to 1990.

Table 3-40 Emission trends of the fugitive emissions subsector (1.B)

IPCC Category			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
1.B.1 Solid Fuels	a. Coal Mining	i. Underground Mines	Gg-CH_4	153.06	63.42	35.16	2.66	1.55	1.67	1.65	1.58	1.65
		ii. Surface Mines	Gg-CH_4	1.01	0.58	0.51	0.43	0.63	0.53	0.47	0.55	0.60
1.B.2 Oil and Natural Gas	a. Oil		Gg-CH_4	1.35	1.75	1.42	1.41	1.30	1.21	1.17	1.12	1.11
	b. Natural Gas		Gg-CH_4	8.95	9.87	10.98	13.30	15.35	14.81	14.07	14.07	13.50
	c. Venting and Flaring	- Venting	Gg-CH_4	0.58	0.86	0.53	0.51	0.47	0.43	0.40	0.39	0.39
		- Flaring	Gg-CH_4	0.11	0.14	0.11	0.13	0.14	0.13	0.12	0.12	0.12
Total			Gg-CH_4	165.06	76.63	48.72	18.43	19.44	18.77	17.89	17.83	17.37
			Gg-CO_2 eq.	3,466.24	1,609.19	1,023.20	387.09	408.29	394.26	375.74	374.43	364.74
1.B.1 Solid Fuels	a. Coal Mining	i. Underground Mines	Gg-CO_2	NE	NE	NE	NE	NE	NE	NE	NE	NE
		ii. Surface Mines	Gg-CO_2	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.2 Oil and Natural Gas	a. Oil		Gg-CO_2	0.14	0.20	0.14	0.15	0.12	0.11	0.09	0.09	0.09
	b. Natural Gas		Gg-CO_2	0.25	0.27	0.31	0.38	0.45	0.43	0.41	0.41	0.39
	c. Venting and Flaring	- Venting	Gg-CO_2	0.0050	0.0075	0.0046	0.0044	0.0041	0.0037	0.0035	0.0034	0.0034
		- Flaring	Gg-CO_2	36.22	50.44	35.58	37.06	37.27	34.60	32.64	32.03	31.23
Total			Gg-CO_2	36.62	50.92	36.03	37.60	37.85	35.15	33.14	32.52	31.71
1.B.1 Solid Fuels	a. Coal Mining	i. Underground Mines	Gg-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE
		ii. Surface Mines	Gg-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE
1.B.2 Oil and Natural Gas	a. Oil		Gg-N_2O	3.06E-07	3.40E-07	3.74E-07	5.10E-07	2.72E-07	2.04E-07	6.80E-08	6.80E-08	6.80E-08
	b. Natural Gas		Gg-N_2O									
	c. Venting and Flaring	- Venting	Gg-N_2O									
		- Flaring	Gg-N_2O	0.00036	0.00050	0.00036	0.00038	0.00039	0.00036	0.00034	0.00034	0.00033
Total			Gg-N_2O	0.00036	0.00050	0.00036	0.00038	0.00039	0.00036	0.00034	0.00034	0.00033
			Gg-CO_2 eq.	0.11	0.16	0.11	0.12	0.12	0.11	0.11	0.10	0.10
Total of all gases			Gg-CO_2 eq.	3,502.98	1,660.27	1,059.34	424.80	446.26	429.52	408.98	407.06	396.54

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) Source/Sink Category Description

Coal contains CH_4 that forms 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.

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 shown a yearly decrease.

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 also if compared with other countries.

Although a reporting column is provided for CO_2 emissions associated with coal mining, in the absence of a default emission factor, emissions from this source are reported as “NE”. Coal mining exists in Japan, and, depending on the CO_2 concentration in the coal being mined, CO_2 may be released into the atmosphere during mining activity. Although it is believed that coal beds in Japan do not contain CO_2 at a concentration level that is higher than that in the atmosphere, emissions cannot be calculated because of the absence of actual measurements. Because of the absence of measurements as well as of a default value for CO_2 emissions associated with coal mining, emissions from this source are not reported.

b） Methodological Issues

- ***Estimation Method***

➢ *Mining Activities*

CH_4 emissions from mining activities were drawn from actual measurements obtained from individual coal mines using the Tier 3 method, in accordance with the decision tree of the *GPG (2000)* (Page 2.72, Fig. 2.10).

➢ *Post-Mining Activities*

CH_4 emissions from post-mining activities were estimated using the Tier 1 method, which uses default emission factors in accordance with the decision tree of the *GPG (2000)* (Page 2.73, Fig. 2.11). The emissions were estimated by multiplying the amount of coal mined from underground mines by the emission factor.

- ***Emission Factors***

➢ *Mining Activities*

The emission factor for mining activities was 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 1991 to 1994, since actual measurement data cannot be obtained, the emission factors for those years were interpolated using 1990 and 1995 values, which were established from actual measurements.

Table 3-41 Emission factors for mining activities –underground mines

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	Reference
Coal production of underground mines	kt	6,775	5,622	2,364	738	536	575	588	543	528	Surveyed by J-COAL
CH_4 total emissions	1000 m^3	261,994	91,992	56,502	4,210	1,989	2,079	1,966	1,761	1,763	Surveyed by J-COAL
CH_4 total emissions	Gg-CH_4	175.5	61.6	37.9	2.8	1.3	1.4	1.3	1.2	1.2	=CH_4 [1000m^3] / 1000 X 0.67 [Gg/$10^6 m^3$]
Emission factor	kg-CH_4/t	25.9	11.0	16.0	3.8	2.5	2.4	2.2	2.2	2.2	CH_4 total emissions / coal production of underground mines

➢ *Post-Mining Activities*

Due to the lack of data for emissions from post-mining activities in Japan, the emission factors were calculated (1.64 [kg-CH_4/t]) by converting the median value (2.45 [m^3/t]) of the default values (0.9 – 4.0 [m^3/t]) given in the *Revised 1996 IPCC Guidelines* by the density of CH_4, 0.67 [Gg/10^6 m^3]) at 20°C and 1 atmosphere.

● ***Activity Data***

➢ *Mining Activities, Post-Mining Activities*

The values used for activity data for underground mining and post-mining activities were 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 3-42 Trends in coal production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total coal production	kt	7,980	6,317	2,974	1,249	1,290	1,206	1,145	1,195	1,247
Surface mines	kt	1,205	695	610	511	754	631	557	652	719
Underground mines	kt	6,775	5,622	2,364	738	536	575	588	543	528

● ***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. 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 3-43 Trends in CH_4 recovery from mining activities

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Recovery	1000 m^3	50,139	11,112	9,810	2,044	988	990	941	733	591

➢ *Post-Mining Activities*

The CH_4 recovery/flaring are reported as “NE,” because the existence of such activities has not been confirmed,

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainty for CH_4 emissions from mining activities was calculated to be 5% based on the values of measurement error and error of gas flow velocity fluctuation.

The uncertainty for CH_4 emissions from post-mining activities was 200%, which is the value of the default data in the *GPG (2000)*. A summary of uncertainty assessment methods is provided in Annex 7.

● ***Time-series Consistency***

The CH_4 total emissions data for mining activities in underground mines have been derived from J-COAL statistics consistently 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 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.

The CH_4 recovery data for mining activities are consistent, as was the case for the total coal production and coal production in surface mines.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

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) Source-specific Recalculations

CH_4 recovery from coal mining from FY 1990 to FY 2011 was recalculated from “NE” to estimates. And CH_4 total emissions from coal mining were recalculated.

f) Source-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) Source/Sink Category Description

This category provides the estimation methods for fugitive emissions of CH_4 occurring during coal mining and post-mining activities in surface mines. The emissions of CH_4 recovered/flared and CO_2 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***

➢ *Mining Activities*

The CH_4 emissions were calculated using the Tier 1 method and the default emission factor in accordance with the decision tree of the *GPG (2000)* (Page 2.71, Fig. 2.9).

➢ *Post-Mining Activities*

The CH_4 emissions were calculated using the Tier 1 method and the default emission factor in accordance with the decision tree of the *GPG (2000)* (Page 2.73, Fig. 2.11).

Both were calculated by multiplying the amount of coal mined from surface mines by the relevant emission factor.

● ***Emission Factors***

➢ *Mining Activities*

The value of 0.77 [kg-CH_4/t-coal] was used as emission factor for mining activities. It was derived by converting the median (1.15 [m^3/t]) of the default values given in the *Revised 1996 IPCC Guidelines* (0.3–2.0 [m^3/t]), using the concentration of CH_4 at one atmospheric pressure and 20°C (0.67 [Gg/$10^6 m^3$]).

➢ *Post-Mining Activities*

The value of 0.067 kg-CH_4/t-coal was used as emission factor for post-mining activities. It was derived by converting the median (0.1 m^3/t) of the default values given in the *Revised 1996 IPCC Guidelines* (0–0.2 m^3/t), using the concentration of CH_4 at one atmospheric pressure and 20°C (0.67 Gg/$10^6 m^3$).

● ***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 3-42).

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainties for emission factors, the default values (200%) given in the *GPG (2000)* were applied. The uncertainty of activity data was 10%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties of CH_4 emissions from surface mines were estimated to be 200% for both mining and post-mining activities. A summary of uncertainty assessment methods are provided in Annex 7.

● ***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）Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e）Source-specific Recalculations

There have been no recalculations of emissions from this source category.

f）Source-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.1.2. Solid Fuel Transformation (1.B.1.b.)

In Japan, the production of briquettes is believed to meet the description of the activity of conversion to solid fuel. 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, as no actual measurements have been taken, it is presently not possible to calculate emissions. CO_2, CH_4 and N_2O emissions associated with the conversion to solid fuel were reported as "NE" in the absence of default values.

3.3.2. Oil and Natural Gas (1.B.2.)

3.3.2.1. Oil (1.B.2.a.)

3.3.2.1.a. Exploration (1.B.2.a.i.)

a）Source/Sink Category Description

This category provides the estimation methods for fugitive emissions of CO_2, CH_4 and N_2O occurring during the exploratory drilling of oil and gas fields and pre-production tests.

b）Methodological Issues

● ***Estimation Method***

CO_2, CH_4 and N_2O emissions associated with oil exploratory drilling and pre-production testing were calculated using the Tier 1 method in accordance with the decision tree of *GPG (2000)*. The emissions were calculated by multiplying the number of exploratory drilling wells, and the number of wells tested for oil and gas during pre-production testing, by their respective emission factors.

● ***Emission Factors***

The emission factors from the *GPG (2000)* for drilling and testing wells were used.

Table 3-44 Emission factors for exploratory drilling and testing wells [Gg/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), p. 2.86, Table 2.16

● ***Activity Data***

➢ *Drilling*

The data given in the *Natural Gas Data Year Book* compiled by the Japan Natural Gas Association were used for exploratory drilling wells.

➢ *Testing*

It is not possible to readily ascertain statistically the number of wells in which oil and gas testing had been carried out, and even where such tests had been conducted, not all wells have been successful. For that reason, the median values of the number of exploratory drilling wells and the number of successful wells shown in the *Natural Gas Data Year Book* were used as number of wells tested for oil and gas. For the most recent year, the data of the previous year were provisionally used.

Table 3-45 Trends in the number of exploratory drilling wells and those tested for oil and gas

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of wells drilled	well	8	7	7	10	7	4	2	2	2
Number of wells succeeded	well	1	3	4	5	1	2	0	0	0
Number of wells tested	well	5	5	6	8	4	3	1	1	1

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

Because all emission factors for exploration of oil and natural gas were the default values in the *GPG (2000)*, the uncertainties for emission factors were assessed based on the default values (25%) described in the *GPG (2000)*. The uncertainty of activity data was 10%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for emissions were estimated to be 27% each for the fugitive emissions of CO_2, CH_4, and N_2O that occur during the exploration of oil and natural gas. A summary of uncertainty assessment methods is provided in Annex 7.

● ***Time-series Consistency***

Consistent values have been used as emission factors since FY1990. The activity data have been calculated by using the annual data from the *Natural Gas Data Year Book*, by a consistent estimation method since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

There have been no recalculations of emissions from this source category.

f） Source-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.1.b. Production (1.B.2.a.ii.)

a） Source/Sink Category Description

This category provides the estimation methods for fugitive emissions of CO_2 and CH_4 occurring during the production of crude oil, as well as when measuring instruments are lowered into the oil wells during inspection of operating oil fields.

b） Methodological Issues

● ***Estimation Method***

The emissions relating to fugitive emissions from petroleum production and servicing of oil field production wells were calculated using the Tier 1 method in accordance with the decision tree of the *GPG (2000)* (Page 2.81, Fig. 2.13). The emissions were calculated by multiplying the amount of crude oil production by the emission factor.

● ***Emission Factors***

➢ *Production*

The default value for conventional crude oil given in the *GPG (2000)* was used for the emission factor of fugitive emissions from petroleum production. (The median of the default values was used for CH_4).

Table 3-46 Emission factors for fugitive emissions from petroleum production [Gg/10^3kl]

		CH_4 1)	CO_2	N_2O 2)
Conventional Oil	Fugitive emissions	1.45×10^{-3}	2.7×10^{-4}	0

Source: GPG (2000) Table 2.16

1) The default value is 1.4×10^{-3} – 1.5×10^{-3}

2) Excluded from calculations, as the default value is 0 (zero)

➢ *Servicing*

The default value given in the *GPG (2000)* was used as emission factor for fugitive emissions from the servicing of petroleum production wells.

Table 3-47 Emission factors for fugitive emissions from servicing of petroleum production wells [Gg/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 values for crude oil production in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* prepared by the Ministry of Economy, Trade and Industry were used as activity data for fugitive emissions from production. However, condensates were not included.

➢ *Servicing*

Because the number of oil wells and natural gas wells cannot be separated, the total fugitive emissions from the servicing of oil and natural gas wells are reported in subcategory *1.B.2.b.ii. Production/Processing*. The oil is reported as “IE” here.

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (25% for CO_2 and 25% for CH_4) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for both CO_2 and CH_4. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

For emission factors, consistent values have been used since FY1990. The activity data have been calculated using the annual data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* prepared by the Ministry of Economy, Trade and Industry, in a consistent manner since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

There have been no recalculations of emissions from this source category.

f） Source-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.1.c. Transport (1.B.2.a.iii.)

a） Source/Sink 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 emissions relating to fugitive emissions associated with transport were calculated using the Tier 1 method in accordance with the decision tree of the *GPG (2000)* (Page 2.81, Fig. 2.13). The emissions were calculated by multiplying the amount of crude oil or condensate production by the emission factors.

Fugitive emissions from transporting oil from domestic oil field at sea to land and fugitive emissions from land transport were 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, it has been assumed in the estimation that all of the produced oil is transported by tank trucks or tank cars.

- ***Emission Factors***

The default values given in the *GPG (2000)* were used as emission factors.

Table 3-48 Emission factors for transportation of crude oil and condensate [$Gg/10^3kl$]

	CH_4	CO_2	N_2O 1)
Transportation of crude oil	2.5×10^{-5}	2.3×10^{-6}	0
Transportation of condensate	1.1×10^{-4}	7.2×10^{-6}	0

Source: GPG (2000) Table 2.16

1) Excluded from calculations, as the default value is 0 (zero)

- ***Activity Data***

The amount of oil production in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* prepared by the Ministry of Economy, Trade and Industry, were used as activity data for fugitive emissions from transport.

Table 3-49 Production of crude oil and condensate in Japan

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Oil production excluding condensate	kl	420,415	622,679	385,565	370,423	340,593	309,526	292,539	283,932	281,166
Condensate production	kl	234,111	242,859	375,488	540,507	632,654	607,672	560,106	540,510	477,789
Oil production (total)	kl	654,526	865,538	761,053	910,930	973,247	917,198	852,645	824,442	758,955

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (25% for CO_2 and 25% for CH_4) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for both CO_2 and CH_4. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

For the emission factors, consistent values have been used since FY1990. The activity data have been calculated using the annual data from the *Yearbook of Production, Supply and Demand of Petroleum,* *Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* prepared by the Ministry of Economy, Trade and Industry, by a consistent estimation method since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

There have been no recalculations of emissions from this source category.

f） Source-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） Source/Sink 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 were reported as “NE”. Refining/storage activities exist in Japan and an extremely small amount of CO_2 may 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, CO_2 emissions from this source were not estimated.

b） Methodological Issues

● ***Estimation Method***

➢ *Oil Refining*

The emissions relating to fugitive emissions from refining were calculated using the Tier 1 method in accordance with the decision tree of the *GPG (2000)* (Page 2.82, Fig. 2.14).

➢ *Oil Storage*

The emissions relating to fugitive emissions from storage should be calculated using the Tier 1 method in accordance with the decision tree of the *GPG (2000)* (Page 2.82, Fig.2.14), but as a country-specific emission factor is available for this emission source, this emission factor was applied in the inventories instead.

● ***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 was considered to be negligible because no fugitive emission of CH_4 was 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 *Revised 1996 IPCC Guidelines* was adopted.

Table 3-50 Emission factor during refining of crude oil

Emission factor [kg-CH_4/PJ]	
Oil refining	90[1)]

Source: Revised 1996 IPCC Guidelines, Volume 3 Table 1-58

1) The default value is 90–1,400

➢ *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 modeling the floating-roof tank to calculate estimates of CH_4 emissions.

The emission factor associated with the storage of crude oil is a value derived by converting the estimates of the Petroleum Association (0.007 Gg-CH_4/year as of 1998) to a net calorific value and dividing it by the relevant activity data.

Table 3-51 Assumptions for calculation of emission factor during oil storage

CH_4 emissions [kg-CH_4/year]	Input of crude oil to oil refining industry		Emission factor [kg-CH_4/PJ]
	[PJ: gross calorific value] [1)]	[PJ: net calorific value][2)]	
7,000	9,921	9,424.95	0.7427

1) Agency for Natural Resources and Energy, *General Energy Statistics*

2) Net calorific value = gross calorific value ×0.95

● ***Activity Data***

The values used for activity data during refining and storing were the converted net calorific values of NGL (Natural Gas Liquids) and refined crude oil in the petroleum refining industry taken from the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy.

Table 3-52 Amount of crude oil and NGL refined in Japan

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Oil and NGL refined	PJ:NCV	7,732	8,907	8,898	8,820	8,054	7,542	7,505	7,109	7,101

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

For the uncertainty of emission factors for fugitive emissions of CH_4 occurring when crude oil is refined or stored at oil refineries, the values shown in the *Revised 1996 IPCC Guidelines* are applied. For the uncertainties for emission factors, the default values (25%) indicated in the *GPG (2000)* in accordance with the decision tree of uncertainty assessment of emission factors were applied. The uncertainty for activity data was evaluated to be 0.9% by combining the uncertainty of crude oil and that of NGL indicated in the *General Energy Statistics*. As a result, the uncertainties for emissions were determined to be 25% for CH_4 emissions from the source. A summary of uncertainty assessment methods is provided in Annex 7.

● ***Time-series Consistency***

Consistent values have been used for emission factors since FY1990. The activity data have been calculated using the annual data from the *General Energy Statistics*, by a consistent estimation method since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

The GHG emissions in FY2009 and FY2011 were recalculated because of the revision of the fuel consumption in FY2009 and FY2011 in the *General Energy Statistics*.

f） Source-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 are no measurements of the CO_2 or CH_4 content of petroleum products, it is not currently possible to calculate emissions. The emissions were reported as “NE” in 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.)

There are test drillings of oil and gas fields in Japan, and it is conceivable that the activity could give rise to emissions of CO_2, CH_4, or N_2O. It is difficult, however, to distinguish between oil fields and gas fields prior to test drilling, therefore the emissions were reported as “IE” because the calculation was combined with the subcategory of *1.B.2.a.i. Fugitive Emissions Associated with Oil Exploration*.

3.3.2.2.b. Production / Processing (1.B.2.b.ii.)

a） Source/Sink Category Description

This category provides the estimation methods for fugitive CO_2 and CH_4 emissions from the production of natural gas, processing through the adjustment of its constituent elements, and through the lowering of measuring instruments during the servicing of natural gas production wells.

b） Methodological Issues

● ***Estimation Method***

Fugitive emissions from the production of natural gas, processing through the adjustment of its constituent elements, and through the lowering of measuring instruments during the servicing of natural gas production wells were calculated using the Tier 1 method, and in accordance with the decision tree of the *GPG (2000)* (Page 2.80, Fig. 2.12).

The fugitive emissions during natural gas production and conditioning processes were estimated by multiplying the amount of natural gas production by their respective emission factors. The fugitive emissions during gas field inspections were calculated by multiplying the number of production wells by the emission factor.

● ***Emission Factors***

➢ *Production*

The default values given in the *GPG (2000)* were used for the emission factors of fugitive emissions during the production of natural gas. (The median of the default values was used for CH_4).

Table 3-53 Emission factors of fugitive emissions during production of natural gas [Gg/10^6 m^3]

		CH_4 1)	CO_2	N_2O 2)
Natural gas production	Fugitive emissions	2.75×10^{-3}	9.5×10^{-5}	0

Source: GPG (2000) Table 2.16

1) The default values are 2.6×10^{-3} – 2.9×10^{-3}

2) Excluded from calculations, as the default value is 0 (zero)

➢ *Processing*

The default values given in the *GPG (2000)* for the emission factors of fugitive emissions during processing of natural gas were used. (The median of the default values was used for CH_4).

Table 3-54 Emission factors during processing of natural gas [Gg/10^6 m^3]

		CH_4 1)	CO_2	N_2O 2)
Processing of natural gas	Processing in general (general treatment plant, sweet gas plants)	8.8×10^{-4}	2.7×10^{-5}	0

Source: GPG (2000) Table 2.16

1) The default values are 6.9×10^{-4} – 10.7×10^{-4}

2) Excluded from calculations, as the default value is 0 (zero)

➢ *Servicing*

The default values for fugitive emissions during the servicing of natural gas production wells given in the *GPG (2000)* were used.

Table 3-55 Emission factors during servicing of natural gas production wells [Gg/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 and Processing*

The production volume of natural gas in Japan given in the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* prepared by the Ministry of Economy, Trade and Industry, was used as activity data during its production and processing.

➢ *Servicing*

Because the number of oil wells and natural gas wells cannot be separated for the entire time series, the total fugitive emissions from servicing of oil and natural gas wells are reported here. The number of oil/natural gas wells shown in the *Natural Gas Data Year Book* published by the Japan Natural Gas Association was used. As for the most recent year, the data of the previous year was provisionally used.

Table 3-56 Natural gas production and the number of producing and capable wells

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Natural gas production	$10^6 m^3$	2,066	2,237	2,499	3,140	3,706	3,555	3,343	3,334	3,177
Number of producing and capable wells	well	1,230	1,205	1,137	1,115	1,065	1,049	1,046	1,047	1,047

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors for the fugitive CO_2 and CH_4 emissions during the production and processing of natural gas, the default values given in the *GPG (2000)* (25% for CO_2 and 25% for CH_4) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for both CO_2 and CH_4.

As the uncertainty of emission factors for the fugitive CO_2 and CH_4 emissions from the servicing of oil and natural gas wells, the default values given in the *GPG (2000)* (25% for CO_2 and 25% for CH_4) were applied. The uncertainty of activity data was 10%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 27% for both CO_2 and CH_4.

The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Consistent values have been used for emission factors since FY1990. The activity data have been calculated by using the annual data on the production volume of natural gas from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* 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 estimation method has been used since FY1990.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） *Source-specific Recalculations*

Since the activity data for FY2011 were obtained, the GHG emissions of FY2011 were recalculated.

f） *Source-specific Planned Improvements*

There are no major planned improvements in this source category.

3.3.2.2.c. Transmission (1.B.2.b.iii.)

a） *Source/Sink Category Description*

This category provides the estimation methods for CH_4 emissions in conjunction with 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.

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 formations 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 emission of CO_2 removed at natural gas production plants is assigned to natural gas production and processing (1.B.2.b.ii).

b） *Methodological Issues*

● ***Estimation Method***

The total length of natural gas pipeline is multiplied by a Japan-specific emission factor to calculate CH_4 emissions occurring in conjunction with releases by pipeline construction and relocation, and releases of gas used to operate pressure regulators.

● ***Emission Factors***

The amount of CH_4 emitted from a 1-km long domestic natural gas pipeline over a 1-yearperiod is defined as the emission factor, and is set by dividing the CH_4 emission amount by pipeline length. Due to the insufficiency of past data, it was decided that a uniform emission factor set using FY2004 data, should be used for 1990 and subsequent years. The data were provided by the Japan Natural Gas Association.

1） *Gas Releases Due To Pipeline Relocation*

The equation below was used as the basis for calculating the CH_4 amount released when in-pipe pressure is reduced for relocating gas pipelines. Further, after relocation work is complete it is necessary to flush the pipeline with natural gas, which is released before introduction into the pipeline. The amount of CH_4 is determined by measuring it with a gas meter or calculating it using means such as pipeline pressure when introducing the gas. These amounts were calculated for each pipeline relocation and the annual cumulative total was determined.

Amount of CH_4 emissions = volume of pipe section with reduced pressure × pressure before reduction (absolute pressure) / atmospheric pressure (absolute pressure) × CH_4 content [CH_4 per m^3N]

2) Gas Releases Due To Pipeline Installation

After installation work is completed, it is necessary to flush the pipeline with natural gas, which is released before introduction into the pipeline. The amount of CH_4 is determined by measuring it with a gas meter or calculating it using means such as pipeline pressure when gas is introduced, and their annual cumulative total is determined.

3) Release of Gas for Operating Pressure Regulators

The amount of natural gas used in accordance with specifications of pressure regulators for reducing gas supply pressure is calculated as follows.

Amount of CH_4 emission = amount used according to pressure regulator specifications × number of regulators installed ×CH_4 content [CH_4 per m³N]

Table 3-57 FY2004 CH_4 emissions as a concomitant of natural gas transportation

	Amount of gas used [m^{3}N/day]	Number of works	Number of establishments	Amount of gas released [k-m^{3}N]	CH_4 content [t-CH_4/kNm^3]	CH_4 releases [t-CH_4]
Pipeline relocation & installation	-	77	-	843	0.645	544
Gas for operating pressure regulators	19	-	48	333	0.643	215
Total	-	-	-	-	-	759

➢ *Total Pipeline Length*

We used 2,090 km as the total length of natural gas pipeline of the main association members covered by an FY2004 study by the Japan Natural Gas Association, which is the pipeline whose emissions are of concern here.

Emission factor = Amount of CH_4 release / total pipeline length
=759 [t-CH_4] / 2090 [km]
=0.363 [t-CH_4/km]

● ***Activity Data***

The length of natural gas pipeline laid in Japan given by the Japan Natural Gas Association in its *Natural Gas Data Year Book* was used as activity data of the length of natural gas pipeline laid. As for the most recent year, the data of the previous year was provisionally used.

Table 3-58 Length of natural gas pipeline installation

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Length of natural gas pipelines	km	1,984	2,195	2,434	2,721	3,016	3,027	3,030	3,039	3,039

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

A country-specific emission factor is used for CH_4 emissions in conjunction with transportation. As the uncertainty of emission factor, the default value given in the *GPG (2000)* (25% for CH_4) was applied because according to the decision tree, either expert judgment or the default value given in the *GPG (2000)* is to be adopted. The uncertainty of activity data was 10%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 27% for CH_4. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Consistent values have been used for emission factors since FY1990. The activity data have been calculated using the annual data from the *Natural Gas Data Year Book*, by a consistent estimation method since FY1990.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e) Source-specific Recalculations

Since the activity data for FY2011 were obtained, the GHG emissions of FY2011 were recalculated.

f) Source-specific Planned Improvements

The CH_4 emissions in conjunction with transportation of domestically produced natural gas are estimated on the premise that the full transportation of natural gas is sent by pipelines (1.B.2.b.iii), however, recently there are some cases of the transportation of LNG by tank trucks or tank cars. LNG transported by tank trucks and tank cars is basically sealed. There is no research on the actual situation for the whole of Japan, and no default value either, so this current estimation method is continuously adopted. If sufficient data on CH_4 emissions from transportation of natural gas by tank trucks or tank cars is obtained in the future, the possibilities of other estimation methods for this category will be considered.

3.3.2.2.d. Distribution (1.B.2.b.iv.-)

a) Source/Sink Category Description

This category provides the estimation methods for CH_4 emitted from the normal operation of LNG receiving terminals, town gas production facilities, and satellite terminals, as well as during regular maintenance or construction, and 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. (Figure 3-3)

Japan reports the emissions associated with the production of town gas (Natural Gas Supplies) in the category of *1.B.2.b. Natural Gas Distribution*. The town gas production is accounted for in this category, even though it may not meet the definition in the *Revised 1996 IPCC Guidelines* exactly, because of the lack of a category more appropriate for reporting emissions from town gas production.

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 formations 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 assigned to natural gas production and processing (1.B.2.b.ii).

b） Methodological Issues

● Estimation Method

➢ *LNG Receiving Terminals, Town Gas Production Facilities, and Satellite Terminals (Natural Gas Supplies)*

Some of the main emission sources are gas samples taken for analysis and residual gas emitted at times such as regular maintenance of manufacturing facilities. The Tier 1 method is employed in accordance with the *GPG* (2000) decision tree (page 2.82, Fig. 2.14). However, because it is possible to use a Japan-specific emission factor, the amounts of liquefied natural gas and natural gas used as town gas feedstock were multiplied by a Japan-specific emission factor to obtain emissions.

➢ *Town Gas Supply Networks*

CH_4 emissions from high-pressure pipelines and from medium- and low-pressure pipelines and holders are calculated by multiplying the total length of town gas pipeline by the emission factor. CH_4 emissions from service pipes are calculated by multiplying the number of users by the emission factor.

● Emission Factors

➢ *LNG Receiving Terminals, Town Gas Production Facilities, and Satellite Terminals (Natural Gas Supplies)*

The emission factor was calculated by dividing the emissions of CH_4 during the normal operation of LNG receiving terminals, town gas production facilities, and satellite terminals in Japan, as well as during regular maintenance or construction, by the calorific value of the raw material input (LNG, natural gas). The emission factor calculated using the FY1998 data was 905.41 [kg-CH_4/PJ], while that calculated using the FY2007 data was 264.07 [kg-CH_4/PJ]. The main reason for the change in emission factor was the reduction in CH_4 emissions, which was due to the progress in reduction measures such as the installation of new sampling and recovery lines used for gas analyses (changes to lines that recover gas from atmospheric dispersion) in LNG receiving terminals and town gas production facilities. Because measures to reduce CH_4 emissions have been implemented gradually, the emission factors for the period from FY1999 to FY2006 were set by linear interpolation. At this 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 will be kept for FY2008 and subsequent years.

➢ *Town Gas Supply Networks*

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. FY2004 data were used to calculate CH_4 emissions for each of the minor categories of each of the emission sources shown in Table 3-51. The emission factor for high-pressure pipelines and for medium- and low-pressure pipelines and holders was set using the CH_4 amount emitted from 1 km of the town gas pipeline length during 1 year, while that for service pipes was set using the CH_4 amount emitted from 1000 users' homes during 1 year.

Table 3-59 CH_4 emissions from town gas pipelines and emission factors (Established by FY2004 data)

Emission sources		CH_4 emissions [t/year]	Activity data	Emission factors
High-pressure pipelines	New pipeline installation Pipeline relocation	180	Total high-pressure pipeline 1799 [km]	0.100 [t-CH_4/km]
Medium- and low-pressure pipelines and holders	Construction and demolition Fugitive emissions Burner and other inspections Holder construction and overhauling	93	Total medium- and low-pressure pipeline 226,016 [km]	0.411 [kg-CH_4/km]
Service pipes	Installation of service pipes Post-installation purging Removal Change of meters Fugitive emissions, etc. Rounds for opening valves and regular maintenance Equipment repairs (Especially high emissions when doing work at user sites (homes))	19	User homes 27,298,000	0.696 [kg-CH_4/1000 homes]

● ***Activity Data***

➢ *LNG Receiving Terminals, Town Gas Production Facilities, and Satellite Terminals (Natural Gas Supplies)*

The amounts of LNG and natural gas shown in the *General Energy Statistics* (Agency for Natural Resources and Energy) were used as raw material for town gas.

Table 3-60 Liquefied natural gas and natural gas used as material for town gas

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
LNG consumption with town gas production	PJ	464	676	864	1,230	1,439	1,424	1,553	1,591	1,590
Natural gas consumption with town gas production	PJ	40	48	61	86	131	127	115	128	121

➢ *Town gas supply networks*

For the estimates, the length of high-pressure pipelines, total medium- and low-pressure pipelines and the number of users given in the *Gas Industry Yearbook* of the Agency for Natural Resources and Energy, Gas Market Division were used.

Table 3-61 Length of high-pressure pipelines, total medium- and low-pressure pipelines, and number of users

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Length of high-pressure pipelines	km	1,067	1,281	1,443	1,898	2,029	2,066	2,124	2,196	2,220
Total length of medium- and low-pressure pipelines	km	180,239	197,474	214,312	230,430	239,336	241,675	244,022	246,197	248,429
Number of users	10^3 houses	21,334	23,580	25,858	27,762	28,599	28,774	28,902	29,041	29,230

c）Uncertainties and Time-series Consistency

- ***Uncertainties***

Although the CH_4 emission factor of natural gas supplies is country-specific, for the uncertainty of emission factor the default value (25%) given in the *GPG (2000)* was adopted, because the application of statistical treatment was considered to be unsuitable. The uncertainty of activity data was determined to be 8.7% by combining the uncertainty of LNG and that of natural gas presented in the *General Energy Statistics*. As a result, the uncertainty for emissions was estimated to be 26% for CH_4 emissions from natural gas supplies.

A country-specific emission factor is used for CH_4 emissions from town gas supply networks. As the uncertainty for emission factors of the town gas supply network, the default value presented in the *GPG (2000)* (25% for CH_4) was applied because the default value of expert opinion or the *GPG (2000)* was to be adopted in accordance with the decision tree of uncertainty assessment of emission factors. For the uncertainty of activity data, the value set by the Committee for Greenhouse Gas Emission Estimation Methods (10%) was applied. As a result, the uncertainty for emissions was estimated to be 27% for CH_4 emissions from the town gas supply network. A summary of uncertainty assessment methods is provided in Annex 7.

- ***Time-series Consistency***

For the emission factors consistent values as described above since FY1990 have been used. The activity data have been calculated using the annual data on LNG and natural gas consumption and town gas production from the *General Energy Statistics* and data on the town gas supply network from the *Gas Industry Yearbook.* A consistent estimation method has been used since FY1990.

d）Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e）Source-specific Recalculations

There have been no recalculations to emissions from this source category.

f）Source-specific Planned Improvements

There are no major planned improvements in this source category.

3.3.2.2.e. Industrial plants and power station / residential and commercial sectors (1.B.2.b. v.)

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, N_2O emissions from flaring during the above processes.

3.3.2.3.a. Venting (Oil) (1.B.2.c.-venting i.)

a） Source/Sink 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 *GPG (2000)* (Page 2.81, Fig. 2.13) by multiplying the amount of crude oil production by the default emission factors.

● ***Emission Factors***

The default values for conventional oil given in the *GPG (2000)* were used for the emission factors of oil field venting. (The median of the default values was used for CH_4).

Table 3-62 Emission factors of oil field venting

		CH_4 1)	CO_2	N_2O 2)
Conventional oil	Venting valves [Gg/1000 m^3]	1.38×10^{-3}	1.2×10^{-5}	0

Source: GPG (2000) Table 2.16

1) The default values are 6.2×10^{-5} - 270×10^{-5}

2) Excluded from calculations, as the default value is 0 (zero)

● ***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* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* was used as activity data of the fugitive emissions from oil field venting. The production of condensate was excluded from the calculation (see Table 3-49).

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (25% for CO_2 and CH_4) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for both CO_2 and CH_4. The uncertainty assessment

methods are summarized in Annex 7.

● ***Time-series Consistency***

For the emission factors consistent values as described above have been used since FY1990. The activity data have been calculated using the annual data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics*, by a consistent estimation method since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

There have been no recalculations to emissions from this source category.

f） Source-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.)

The CO_2 and CH_4 emissions from venting in the natural gas industry were considered only for the amount during transmission because the *GPG* (2000) provides emissions factors only for transmission. Intentional CO_2 emissions from natural gas pipelines are reported as “NA” because CO_2 emissions during the transmission of natural gas are considered as “NA” (1.B.2.b.iii). Intentional CH_4 emissions from natural gas pipelines are reported as “IE” because they are included in the emissions during natural gas transmission (1.B.2.b.iii).

3.3.2.3.c. Venting (Oil and Gas) (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） Source/Sink 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 *GPG (2000)*, 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 *GPG* (2000) were used. It should be noted that the median values were used for CH_4 emissions.

Table 3-63 Emission factors for flaring in the oil industry

	Unit	CH_4 1)	CO_2	N_2O
Flaring (conventional oil)	$Gg/10^3\ m^3$	1.38×10^{-4}	6.7×10^{-2}	6.4×10^{-7}

Source: GPG (2000), Table 2.16

1) Default value: 0.05×10^{-4} to 2.7×10^{-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* and the *Yearbook of Natural Resources and Petroleum Products*, both published by the Ministry of Economy, Trade and Industry, were used. The production of condensate was excluded from the calculation (see Table 3-41).

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (25% for CO_2, CH_4, and N_2O) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for CO_2, CH_4, and N_2O. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

For the emission factors, consistent values as described above have been used since FY1990. The activity data have been calculated using the annual data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics*, by a consistent estimation method since FY1990.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e) Source-specific Recalculations

There have been no recalculations of emissions from this source category.

f) Source-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.e. Flaring (Natural Gas) (1.B.2.c.-flaring ii.)

a） *Source/Sink 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 *GPG (2000)*. 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 (Natural Gas) given in the *GPG (2000)* were used.

Table 3-64 Emission factors for flaring in the natural gas industry

		Unit	CH_4	CO_2	N_2O
Flaring in the natural gas industry	Gas production	$Gg/10^6m^3$	1.1×10^{-5}	1.8×10^{-3}	2.1×10^{-8}
	Gas processing	$Gg/10^6m^3$	1.3×10^{-5}	2.1×10^{-3}	2.5×10^{-8}

Source: *GPG* (2000), Table 2.16

● ***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* and the *Yearbook of Natural Resources and Petroleum Products*, both published by the Ministry of Economy, Trade and Industry, were used (see Table 3-48).

c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

As the uncertainty of emission factors, the default values given in the *GPG (2000)* (25% for CO_2, CH_4, and N_2O) were applied. The uncertainty of activity data was 5%; this was determined as a standard value by the Committee for the Greenhouse Gas Emission Estimation Methods. As a result, the uncertainties for the emissions were determined to be 25% for CO_2, CH_4, and N_2O. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

For the emission factors consistent values as described above have been used since FY1990. The activity data have been calculated using the annual data from the *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics*, by a consistent estimation method since FY1990.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. The details of the QA/QC activities are provided in Annex 6.

e） Source-specific Recalculations

The GHG emissions in FY2011 were recalculated because of the revision of the activity data in FY2011.

f） Source-specific Planned Improvements

There have been no major planned improvements in this source category.

3.3.2.3.f. Flaring (Oil and Gas) (1.B.2.c.-flaring iii.)

Statistical data are reported for two categories of petroleum and natural gas in Japan. As a result, the fugitive emissions from flaring in the combined petroleum and natural gas industries were reported as “IE” since they were accounted for respectively in the emissions from flaring in the petroleum industry (1.B.2.c.i) and the natural gas industry (1.B.2.c.ii).

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Chapter 4. Industrial Processes (CRF sector 2)

4.1. Overview of Sector

Chemical and physical transformation in industrial processes produce atmospheric GHG emissions. This chapter describes the methodologies of estimating industrial process 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 Annex 6)

Emissions have been estimated for all years, with zero emissions for some years and sources, and 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 is shown in the first table of each category.

Table 4-1 Emission source categories in the industrial processes sector

Emission source categories				CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
2.A Mineral Products	2.A.1	Cement Production		○					
	2.A.2	Lime Production		○					
	2.A.3	Limestone and Dolomite Use		○					
	2.A.4	Soda Ash Production and Use		○					
	2.A.5	Asphalt Roofing		NE					
	2.A.6	Road Paving with Asphalt		NE					
	2.A.7	Other		IE, NO	NA, NO	NA, NO			
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	Carbide Production	Silicon Carbide	○	○				
			Calcium Carbide	○	NA				
	2.B.5	Other	Carbon Black		○				
			Ethylene	○	○	NA			
			1,2-Dichloroethane		○				
			Styrene		○				
			Methanol		NO				
			Coke	IE	○	NA			
2.C Metal Production	2.C.1	Iron and Steel Production	Steel	IE	NA				
			Pig Iron	IE	NA				
			Sinter	IE	IE				
			Coke	IE	IE				
			Use of Electric Arc Furnaces in Steel Production	○	○				
	2.C.2	Ferroalloys Production		IE	○				
	2.C.3	Aluminium Production		IE	NE			○	
	2.C.4	SF6 Used in Aluminium and Magnesium Foundaries	Aluminium						NO
			Magnesium				○		○
2.D Other Production	2.D.1	Pulp and Paper							
	2.D.2	Food and Drink		IE					
2.E Production of Halocarbons and SF_6	2.E.1	By-product emissions: Production of HCFC-22					○		
	2.E.2	Fugitive emissions					○	○	○

(continued on next page)

Emission source categories						CO_2	CH_4	N_2O	HFCs	PFCs	SF_6
2.F Consumption of Halocarbons and SF_6	2.F.1	Refrigeration and Air Conditioning Equipment	Domestic Refrigeration		manufacturing				○	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
			Commercial Refrigeration	Commercial Refrigeration	manufacturing				○	NO	NO
					stocks				○	NO	NO
					disposal				○	NO	NO
				Automatic Vending Machine	manufacturing				○	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
			Transport Refrigeration		manufacturing				IE	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
			Industrial Refrigeration		manufacturing				IE	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
			Stationary Air-Conditioning (Household)		manufacturing				○	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
			Mobile Air-Conditioning (Car Air Conditioners)		manufacturing				○	NO	NO
					stocks				IE	NO	NO
					disposal				IE	NO	NO
	2.F.2	Foam Blowing	Hard Foam	Urethane Foam	manufacturing				○	NO	NO
					stocks				○	NO	NO
					disposal				IE	NO	NO
				High Expanded Polyethylene Foam	manufacturing				○	NO	NO
					stocks				NO	NO	NO
					disposal				NO	NO	NO
				Extruded Polystyrene Foam	manufacturing				○	NO	NO
					stocks				○	NO	NO
					disposal				IE	NO	NO
				Phenol Foam					NO	NO	NO
			Soft Foam						NO	NO	NO
	2.F.3	Fire Extinguishers			manufacturing				NO	NO	NO
					stocks				○	NO	NO
					disposal				NO	NO	NO
	2.F.4	Aerosols/Metered Dose Inhalers	Aerosols		manufacturing				○	NO	NO
					stocks				○	NO	NO
					disposal				IE	NO	NO
			Metered Dose Inhalers		manufacturing				○	NO	NO
					stocks				○	NO	NO
					disposal				IE	NO	NO
	2.F.5	Solvents			manufacturing				NO	NO	NO
					stocks				IE	○	NO
					disposal				IE	IE	NO
	2.F.6	Other Applications Using ODS Substitutes							IE	NA	NA
	2.F.7	Semiconductors	Semiconductors		manufacturing				IE	IE	IE
					stocks				○	○	○
					disposal				NA	NA	NA
			Liquid Crystals		manufacturing				IE	IE	IE
					stocks				○	○	○
					disposal				NA	NA	NA
	2.F.8	Electrical Equipment			manufacturing						○
					stocks						○
					disposal						IE
	2.F.9	Other							NA	NE, ○	IE

○: Emissions reported

Refer to Abbreviations list for notation keys.

In 2012, total GHG emissions from the industrial processes sector amounted to approximately 69,516 Gg-CO_2 eq., accounting for 5.2% of national total emissions (excluding LULUCF) in Japan. The emissions of CO_2, CH_4, and N_2O from this sector has decreased by 38.3% compared to 1990. The emissions of HFCs, PFCs and SF_6 from this sector has decreased by 47.0% compared to 1995.

4.2. Mineral Products (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.), Limestone and dolomite use (2.A.3.) and Soda ash production and use (2.A.4.).
In 2012, emissions from Mineral Products were 38,906 Gg-CO_2 and represented 2.9% of total GHG emissions (excluding LULUCF). The emissions decreased by 29.7% compared to 1990.

Table 4-2 CO_2 Emissions from 2.A. Mineral Products

Gas	Emission sub-category			Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	2.A Mineral Products	2.A.1	Cement production	Gg-CO_2	37,905	41,275	34,394	31,579	27,925	24,755	23,784	24,450	25,060
		2.A.2	Lime production	Gg-CO_2	6,674	5,795	5,900	6,646	6,592	5,365	6,285	5,896	5,670
		2.A.3	Limestone and dolomite use	Gg-CO_2	10,464	9,436	9,243	8,352	8,208	7,332	7,961	7,900	8,034
		2.A.4	Soda ash production and use	Gg-CO_2	267	250	209	197	159	138	146	146	142
	Total			Gg-CO_2	55,311	56,756	49,746	46,774	42,883	37,589	38,177	38,391	38,906

4.2.1. Cement Production (2.A.1.)

a) Source/Sink Category Description

CO_2 is emitted by the calcination of limestone, the main component of which is calcium carbonate, during the production of clinker, an intermediate product of cement and the main component of which is calcium oxide.

<u>CO_2 emission mechanism of the cement production process</u>

$$CaCO_3 \rightarrow CaO + CO_2$$

b) Methodological Issues

- ***Estimation Method***

Following the *GPG (2000)* decision tree, the CO_2 emissions from this source was estimated by multiplying the amount of clinker produced by a country-specific emission factor.

<u>CO_2 emissions [t-CO_2] from cement production</u>

= emission factor [t-CO_2/t-clinker] × clinker production [t] × cement kiln dust correction coefficient

- ***Emission Factors***

Multiplying the CaO content of clinker by the molecular weight ratio of CaO and CO_2 (0.785) yields the country-specific emission factor. Because 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 from sources other than carbonates. This CaO does 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 content of clinker from carbonates, by subtracting CaO originating from waste and other sources from the total CaO 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 calculated using the following procedure.

1 Estimate dry weight of waste and other materials input in raw material processing.
2 Estimate the amount and content of CaO from waste and other materials in clinker.
3 Estimate the CaO content of clinker, excluding the CaO from waste and other materials.
4 Determine the clinker emission factor.

Emission factors of CO_2 emissions from cement production
= [(CaO content of clinker) – (CaO content of clinker from waste and other materials)] × 0.785

CaO content of clinker from waste and other materials
= dry weight of inputs of waste and other materials × CaO content of waste and other materials / clinker production volume

- ***Estimating 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 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 Cement Association of Japan (only for 2000 and thereafter).

- ***Estimating the amount and content of CaO from waste and other materials in clinker***

The dry weights of each type of waste and other materials found above are multiplied by the CaO content for each type as found by the Cement Association, thereby calculating the total CaO amount in clinker derived from waste and other materials. This is divided by clinker production amount to find the CaO content from waste and other materials in clinker. Because data for 1990 to 1999 are unavailable, averages for 2000 through 2003 were used.

- ***Estimating the CaO content of clinker, excluding the CaO from waste and other materials***

CaO content in waste and other materials is subtracted from the average CaO content of clinker as determined by the Cement Association, which yields the proportion of CaO in clinker that is used to set emission factors.

Table 4-3 Composition of waste origin material

Group	Types of waste	Water content	CaO content
Incineration residue	Coal ash	7.2 - 14.5%	5.0 - 5.8%
	Sewage sludge incineration ash *	10.9 - 14.9%	7.4 - 12.5%
	Municipal solid waste incineration ash *	19.2 – 24.4%	10.0 - 26.5%
Glass refuse, Concrete refuse, and Ceramics refuse	Glass refuse, Ceramics refuse *	12.1 - 32.7%	17.5 - 31.1%
	Concrete refuse *	6.3 - 22.2%	6.4 - 43.9%
Slag	Blast furnace slag (water granulated)	5.0 - 14,3%	40.0 - 42.4%
	Blast furnace slag (slow-cooled)	5.7 - 7.4%	40.8 - 41.5%
	Steelmaking slag	7.7 - 14.1%	34.8 - 40.5%
	Nonferrous slag	5.5 - 8.4%	6.4 - 10.0%
	Casting sand *	9.8 – 10.9%	6.5%
Particulates (dust collector dust)	Particulates/dust	8.9 - 14.3%	9.0 - 13.4%
	Coal ash (fluidized bed furnace ash) *	0.1 - 3.2%	14.5 - 20.7%
	Coal ash	1.0 - 3.9%	4.6 - 5.0%

* Newly added from FY2009.

Table 4-4 CO_2 emission factors for cement production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Average CaO content in clinker	%	65.9	65.9	66.0	65.9	65.9	65.8	65.8	65.8	65.8
Waste origin CaO content in clinker	%	2.6	2.6	2.9	2.0	1.9	1.7	1.7	2.0	1.8
CaO content in clinker excluding waste origin CaO	%	63.3	63.3	63.0	63.9	63.9	64.1	64.1	63.7	64.0
CO_2/CaO		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	0.502	0.503	0.503	0.500	0.502

- ***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 4-5 Clinker production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Consumption of limestone (actual)	kt (dry)	89,366	97,311	81,376	-	-	-	-	-	-
Clinker production (actual)	kt	-	-	69,528	63,003	55,647	49,195	47,279	48,884	49,883
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	55,647	49,195	47,279	48,884	49,883

* 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 from cement production, the standard value given in the *GPG (2000)* was applied. For the uncertainty of activity data, the value of 10% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of emissions was estimated to be 10%. The uncertainty assessment methods are summarized in Annex 7.

- ***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 Cement Association. For years from 2000 and onward, the methodology described in the sections above is consistently applied using the data provided by Cement Association.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

4.2.2. Lime Production (2.A.2.)

a） Source/Sink Category Description

CO_2 is emitted during the calcination of $CaCO_3$, $MgCO_3$ in limestone used as raw material to produce quicklime.

<u>CO_2 generation mechanism of quicklime production process</u> $CaCO_3 \rightarrow CaO + CO_2$ $MgCO_3 \rightarrow MgO + CO_2$

b） Methodological Issues

- ***Estimation Method***

CO_2 emissions are calculated by multiplying limestone consumption by the country-specific emission factor.

<u>*CO_2 emissions [t-CO_2] generated by use of raw materials in quicklime production*</u> = 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 Limestone and dolomite use (2.A.3.) ,therefore it 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,

Table 4-6 Limestone consumption

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Limestone consumption (dry)	kt	15,595	13,540	13,785	15,527	15,401	12,534	14,684	13,775	13,248

c) *Uncertainties and Time-series Consistency*

- ***Uncertainty***

The uncertainty for CO_2 emissions from quicklime lime production was estimated. The uncertainty of 15% as given in the *GPG (2000)* was used for emission factors for both types of lime. For the uncertainty of activity data, 5% was used. As a result, the uncertainty of emissions was estimated to be 16%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

Recalculations have been conducted for 2011, based on updates made to limestone consumption data in the Adjusted Price Transaction Table.

f） Source-specific Planned Improvements

No improvements are planned.

4.2.3. Limestone and Dolomite Use (2.A.3.)

a） Source/Sink 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 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.

$CaCO_3 \rightarrow CaO + CO_2$
$MgCO_3 \rightarrow MgO + CO_2$
・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.

$CaCO_3 \rightarrow CaO + CO_2$
$MgCO_3 \rightarrow MgO + CO_2$
・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,' excluding sectors that correspond to Cement production (2.A.1.) and Lime production (2.A.2.) , i.e., ‘Ceramic industry – cement’ and ‘Ceramic industry - other ceramic, stone, and clay products - quicklime and slaked lime,’ will be accounted for under this subcategory (For dolomite, all sectors excluding ‘Ceramic industry – cement’). Activity data is in dry weight, converted using the water content from limestone used for cement.

The sectors in the Adjusted Price Transaction Table corresponding to the five main uses are as follows:

Table 4-7 Main uses and corresponding sectors in the Adjusted Price Transaction Table

Main uses	Corresponding sectors in the Adjusted Price Transaction Table (Limestone)	Corresponding sectors in the Adjusted Price Transaction Table (Dolomite)
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	
Glass products	2511-01 Ceramic industry - sheet glass to 2519-09 Ceramic industry - other glass products	2511-01 Ceramic industry - sheet glass/safety glass
Desulfurization of exhaust gas	0621-01 Mining industry - materials for ceramics	
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
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 4-8 Amounts of limestone and dolomite consumption

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Limestone consumption										
For Steel and Refinement (dry)	kt	14,430	13,590	13,619	12,579	12,203	11,024	11,843	11,575	11,616
For Glass Products (dry)	kt	66	42	26	31	16	12	17	16	19
For Flue Gas Desulfurization (dry)	kt	1,841	2,139	1,813	2,075	1,922	1,699	1,795	2,008	2,146
For Ceramic Products (dry)	kt	442	1,110	1,138	463	528	372	347	361	317
For Chemical Products (dry)	kt	3,668	1,717	1,772	682	749	521	480	493	429
Dolomite consumption										
For Steel and Refinement (dry)	kt	1,144	1,089	1,160	1,530	1,534	1,096	1,575	1,539	1,565
For Glass Products (dry)	kt	264	250	203	230	160	126	151	154	160
For Ceramic Products (dry)	kt	1,561	1,227	1,020	1,130	1,295	1,577	1,615	1,548	1,731
For Chemical Products (dry)	kt	147	96	84	53	35	36	34	30	31

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of emission factors for limestone and dolomite were estimated using expert judgment. The uncertainty of emission factors for limestone and dolomite were determined to be 16.4%, 3.5% respectively. The uncertainty for activity data were estimated as 4.8% and 3.9% for limestone and dolomite, respectively, and the uncertainty for emissions were estimated as 17% and 5%, respectively. The uncertainty assessment methods are summarized in Annex 7.

- ***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) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

Recalculations have been conducted for 2010 and 2011, based on updates made to limestone consumption data in the Adjusted Price Transaction Table, and for 2011, based on updates made to dolomite consumption data in the Adjusted Price Transaction Table.

f) Source-specific Planned Improvements

No improvements are planned.

4.2.4. Soda Ash Production and Use (2.A.4.)

4.2.4.1. Soda Ash Production (2.A.4.-)

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 *Revised 1996 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.

4.2.4.2. Soda Ash Use (2.A.4.-)

a) Source/Sink 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, 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 annual fluctuation in purity of soda ash is small, 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)
x 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 *Revised 1996 IPCC Guidelines* (vol. 3 p. 2.13) is used continuously.

- ***Activity Data***

Soda ash consumption data categorized under 'for emission purpose' in the Adjusted Price Transaction Table is used.

Table 4-9 Soda ash consumption

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Soda ash consumption (soda ash)	kt	647	605	504	476	384	333	353	353	344

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor from soda ash use, the lime production value was applied since it is a similar source category to soda ash. For the uncertainty of activity data, 6.3% uncertainty was applied. The uncertainty of CO_2 emissions from soda ash use was estimated as 16%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

Recalculations have been conducted for 2011, based on updates made to soda ash consumption data in the Adjusted Price Transaction Table.

f） Source-specific Planned Improvements

No improvements are planned.

4.2.5. Asphalt Roofing (2.A.5.)

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”.

4.2.6. Road Paving with Asphalt (2.A.6.)

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”.

4.3. Chemical Industry (2.B.)

This category covers CO_2, CH_4, and N_2O emissions from the processes of chemical productions.
This section includes GHG emissions from five sources: Ammonia production (2.B.2.), Nitric acid production (2.B.2.), Adipic acid production (2.B.3.), Carbide production (2.B.4.), Other (2.B.5.).
In 2012, emissions from Chemical Industry were 3,151 Gg-CO_2 eq. and represented 0.2% of Japan’s total GHG emissions (excluding LULUCF). The emissions had decreased by 75.4% compared to 1990.

Table 4-10 Emissions from 2.B. Chemical Industry

Gas	Emission sub-category				Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	2.B Chemical Industry	2.B.1	Ammonia production		Gg-CO_2	3,385	3,436	3,188	2,155	1,990	1,909	2,106	1,991	1,838
		2.B.4	Carbide production	Silicon carbide	Gg-CO_2	C	C	C	C	C	C	C	C	C
				Calcium carbide	Gg-CO_2	C	C	C	C	C	C	C	C	C
		2.B.5	Other	Ethylene	Gg-CO_2	C	C	C	C	C	C	C	C	C
	Total				Gg-CO_2	4,209	4,220	3,893	2,887	2,574	2,488	2,737	2,629	2,416
CH_4	2.B Chemical Industry	2.B.4	Carbide production	Silicon carbide	Gg-CH_4	C	C	C	C	C	C	C	C	C
		2.B.5	Other	Carbon black	Gg-CH_4	0.28	0.27	0.27	0.28	0.25	0.22	0.26	0.23	0.21
				Ethylene	Gg-CH_4	C	C	C	C	C	C	C	C	C
				1,2-Dichloroethane	Gg-CH_4	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01
				Styrene	Gg-CH_4	C	C	C	C	C	C	C	C	C
				Methanol	Gg-CH_4	0.17	0.15	NO	NO	NO	NO	NO	NO	NO
				Coke	Gg-CH_4	15.47	13.82	8.00	5.02	4.59	4.13	4.45	4.54	4.56
	Total				Gg-CH_4	16.10	14.45	8.50	5.55	5.04	4.58	4.93	4.98	4.97
	Total				Gg-CO_2 eq.	338	304	178	117	106	96	103	104	104
N_2O	2.B Chemical Industry	2.B.2	Nitric acid production		Gg-N_2O	2.47	2.46	2.57	2.52	1.62	1.54	1.81	1.49	1.53
		2.B.3	Adipic acid production		Gg-N_2O	24.20	24.03	12.56	1.68	2.45	3.49	1.66	1.05	0.51
	Total				Gg-N_2O	26.67	26.49	15.13	4.19	4.07	5.03	3.48	2.54	2.04
	Total				Gg-CO_2 eq.	8,267	8,213	4,690	1,300	1,262	1,559	1,078	788	631
Total of All Gases					Gg-CO_2 eq.	12,814	12,736	8,762	4,303	3,942	4,144	3,918	3,521	3,151

C: Confidential

4.3.1. Ammonia Production (2.B.1.)

a) Source/Sink Category Description

1) CO_2

In ammonia production, CO_2 is emitted when hydrocarbon feedstock is broken down to make H_2.

<u>CO_2 generating mechanism of ammonia production</u>

$$0.88CH_4 + 1.26air + 1.24H_2O \rightarrow 0.88CO_2 + N_2 + 3H_2$$

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 sufficient examples to enable the establishment of an emission factor, it is not currently possible to calculate emissions. The *Revised 1996 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.

- ***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 4-11. 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 4-11 Emission factors and calorific values of feedstocks used when producing ammonia

Feedstock	Emission Factors [tC/TJ]	Calorific value		(Units)
		1990	2005	
Naphtha	18.17	33.5	33.6	MJ/l
Liquefied petroleum gas (LPG)	16.13	50.2	50.8	MJ/kg
Refinery gas (Offgas)	14.15	39.3	44.9	MJ/m^3
Natural gas	13.90	41.0	43.5	MJ/m^3
Coal (thermal coal, imports)	24.71	26.0	25.7	MJ/kg
Petroleum coke	25.35	35.6	29.9	MJ/kg
Liquefied natural gas (LNG)	13.47	54.4	54.6	MJ/kg
Coke oven gas (COG)	10.99	20.1	21.1	MJ/m^3

(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 4-12 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 4-12 Amount of feedstocks used for ammonia production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Naphtha	kl	189,714	477,539	406,958	92,453	67,062	72,045	70,067	67,646	67,869
LPG	t	226,593	45,932	5,991	NO	NO	NO	NO	NO	NO
Off gas	10^{3}m^3	C	230,972	240,200	147,502	151,553	140,783	143,634	126,809	NO
Natural gas	10^{3}m^3	C	100,468	86,873	77,299	50,260	21,773	41,640	41,169	45,808
Coal	t	C	209,839	726	1,239	802	522	629	879	390
Oil coke	t	C	273,125	420,862	353,983	336,633	351,594	394,116	365,340	405,557
LNG	t	C	46,501	23,395	165,606	162,342	145,699	157,918	161,588	169,109
COG	10^{3}m^3	C	35,860	55,333	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 values given in Chapter 3 were applied. The standard value, 5%, given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of emissions from the fuels are of the following: naphtha 7%; LPG 6%; hydrocarbon gas 22%; natural gas 7%; coal (steam coal, imported coal) 7%; petroleum coke 23%; LNG 10%; and COG 25%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

4.3.2. Nitric Acid Production (2.B.2.)

a） Source/Sink Category Description

N_2O is emitted when nitric acid (HNO_3) is produced from ammonia.

N2O generating mechanism in nitric acid production

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

$$2NO + H_2O \rightarrow 2NO_2$$

$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO \quad (\rightarrow N_2O)$$

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 method given in *GPG (2000)* (page 3.31, Equation 3.9). Emissions data for individual factories is confidential, therefore the nitric acid production amount and the emission factor were set for Japan's total production. 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, 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 4-13 N_2O emission factors for nitric acid production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
EFs for nitric acid production	kg-N_2O/t	3.50	3.51	3.92	4.18	3.35	3.34	3.58	3.49	3.38

- ***Activity Data***

Production amounts of nitric acid are directly provided by the Ministry of Economy, Trade and Industry.

Table 4-14 Amount of nitric acid production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Nitric acid production	t	705,600	701,460	655,645	602,348	484,070	460,600	506,071	426,349	452,918

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of the emission factor was estimated using a 95% confidence interval for emission factors. For the uncertainty of activity data, the standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of emissions was estimated as 46%. The uncertainty assessment methods are summarized in Annex 7.

- ***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) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

There have been no source-specific recalculations.

f) Source-specific Planned Improvements

No improvements are planned.

4.3.3. Adipic Acid Production (2.B.3.)

a) Source/Sink 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 *GPG (2000)* decision tree (Page 3.32, Fig. 3.4).

<u>*N_2O emissions from adipic acid production*</u>

= [N_2O generation rate × (1 – N_2O generation rate × decomposition unit operation rate)] × adipic acid production rate

- ***Emission Factors***

Values calculated using the above equation has been used as country-specific emission factors. Parameters were established by the following methods. Relevant data used in estimation is confidential.

➢ ***Rate of generation of nitrous oxide***

Actual measurement data provided from the sole producer of adipic acid as an end product in Japan.

➢ ***Rate of decomposition of nitrous oxide***

The figure used is the result of measurement of the rate of decomposition of nitrous oxide in the operating site.

➢ ***Operating rate of decomposition unit***

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.

<u>*Calculation of operating ratio of decomposition unit*</u>

Operating ratio 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 the entire volume 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 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 *GPG (2000)* was applied for activity data. As a result, the uncertainty for adipic acid was estimated as 9%. The uncertainty assessment methods are summarized in Annex 7.

● ***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) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

There have been no source-specific recalculations.

f) Source-specific Planned Improvements

No improvements are planned.

4.3.4. Carbide Production (2.B.4.)

4.3.4.1. Silicon Carbide Production (2.B.4.-)

a) Source/Sink 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 *Revised 1996 IPCC Guidelines* (vol. 3 p. 2.21) 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 3.2.2 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 CO_2 emission factor, 100% was applied as provided by the *GPG (2000)* for a similar category. For the uncertainty of activity data, the standard value of 10% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. The uncertainty assessment methods are summarized in Annex 7.

2） CH_4

The uncertainty of the CH_4 emission factor was estimated as 163%, as estimated in Chapter 3. For the uncertainty of activity data, the standard value of 10% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. The uncertainty for emissions is estimated as 163%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

Recalculations were conducted throughout the time-series for CH_4, due to the revision of activity data originating in an issue raised during review that the previously used activity data might be old.

f） Source-specific Planned Improvements

No improvements are planned.

4.3.4.2. Calcium Carbide Production and Use (2.B.4.-)

a) Source/Sink 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 Chemical Products in Limestone and dolomite use (2.A.3.), 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 is reported here.

<u>CO_2 generator mechanism in the calcium carbide production process</u>

(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 *Revised 1996 IPCC Guidelines*.

- ***Emission Factors***

For years FY1990 to 2007, because Japan does not have measurement data or emission factor data, the default value in the *Revised 1996 IPCC Guidelines* is used.

Table 4-15 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

Source: *Revised 1996 IPCC Guidelines*, vol. 3, p. 2.22.

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, 100% was applied as provided by the *GPG (2000)* for a similar category. For the uncertainty of activity data, the standard value of 10% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty for CO_2 emissions from calcium carbide was estimated as 100%. The uncertainty assessment methods are summarized in Annex 7.

● ***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 on, 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 years upto 1990, and therefore default emission factors are used for FY1990 to FY2007.

d） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations

f） Source-specific Planned Improvements

No improvements are planned.

4.3.5. Other (2.B.5.)

4.3.5.1. Carbon Black Production (2.B.5.-)

a） Source/Sink Category Description

Carbon black is made by breaking down acetylene, natural gas, oil mist, and other feedstocks by incomplete combustion at 1,300°C or higher. The CH_4 in the tail gas (offgas) emitted from the carbon black production process is released into the atmosphere.

b） Methodological Issues

● ***Estimation Method***

CH_4 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 *Revised 1996 IPCC Guidelines*.

● ***Emission Factors***

Five major companies, providing 96% of domestic production, recover CH_4 generated in the carbon black production processes and use it in recovery furnaces and flare stacks. Therefore, there are no emissions during normal operation. The emission factor was established by estimating emissions of CH_4 during routine inspections and the boiler inspection carried out by the five major domestic producers, and taking a weighted average by using production amounts of carbon black. The emission factor is 0.35 [kg-CH_4/t].

Table 4-16 CH_4 emissions and carbon black production by five main domestic producers

	Carbon black production [t/year]	CH_4 emissions [kg-CH_4/year]	Emission factor [kg-CH_4/t]
Total from five main companies	701,079	246,067	0.35

Source: Data provided by the Carbon Black Association (1999 actual results)

- ***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 CH_4 emissions associated with the manufacturing of carbon black.

Table 4-17 Carbon black production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Carbon black production	t	792,722	758,536	771,875	805,461	725,113	634,733	730,352	669,887	612,043

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 54.8%. For the uncertainty of activity data, the standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of carbon black production emissions was estimated at 55%. The uncertainty assessment methods are summarized in Annex 7.

- ***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, CH_4 emissions from carbon black production have been estimated in a consistent manner throughout the time-series.

d） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

The possibility of double counting of CH_4 from furnaces in the Energy sector should be investigated.

4.3.5.2. Ethylene Production (2.B.5.-)

a） Source/Sink 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 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 *Revised 1996 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[1]), 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 4-18 Ethylene production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Ethylene production	kt	5,966	6,951	7,566	7,549	6,520	7,219	6,999	6,474	6,261

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, based on the decision tree for uncertainty assessment. The estimated uncertainty for both CO_2 and CH_4 were 77.2%. For the uncertainty of activity data, the

[1] The assumption was set based on a flaring efficiency of 98% shown in the IPCC GPG (Table 2.16 note e).

standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty for both CO_2 and CH_4 were estimated as 77%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

4.3.5.3. 1,2-Dichloroethane (2.B.5.-)

a） Source/Sink Category Description

1,2-dichloroethane (Ethylene Dichloride) is manufactured by reacting ethylene (C_2H_4) and chorine (Cl_2). The product then passes through washing, refining, and thermolysis processes to become a vinyl chloride monomer (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***

CH_4 emissions from 1,2-dichloroethane production are calculated by multiplying production amount by Japan's country-specific emission factor, in accordance with the *Revised 1996 IPCC Guidelines*.

- ***Emission Factors***

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. 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)

- ***Activity Data***

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 from 1,2-dichloroethane production.

Table 4-19 1,2-Dichloroethane production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
1,2-Dichloroethane production	kt	2,683	3,014	3,346	3,639	3,243	3,213	3,155	2,841	2,558

c） Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty of the CH_4 emission factor for 1,2-dichloroethane production were estimated by finding the 95% confidence interval, based on expert judgment. The uncertainty was estimated as 100.7%. For the uncertainty of activity data, the standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of 1,2-dichloroethane production was estimated as 101%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

4.3.5.4. Styrene Production (2.B.5.-)

a） Source/Sink 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 *Revised 1996 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[2]), 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.

- ***Activity Data***

Styrene monomer production amounts from the Yearbook of Chemical Industries Statistics compiled

[2] See footnote 1.

by the Ministry of Economy, Trade and Industry were used as activity data for CH_4 emissions from styrene production.

Table 4-20 Styrene production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Styrene production	kt	2,227	2,952	3,020	3,375	2,699	3,043	3,019	2,594	2,426

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, based on the decision tree for uncertainty assessment. The estimated uncertainty was 113.2%. For the uncertainty of activity data, the standard value of 5% given by the Committee for the Greenhouse Gas Emission Estimation Methods was used. As a result, the uncertainty of emissions was estimated as 113%. The uncertainty assessment methods are summarized in Annex 7.

- ***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) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

There have been no source-specific recalculations.

f) Source-specific Planned Improvements

No improvements are planned.

4.3.5.5. Methanol Production (2.B.5.-)

a) Source/Sink Category Description

CH_4 is emitted in the production of methanol.

b) Methodological Issues

- ***Estimation Method***

CH_4 emissions from methanol production are calculated using the method given in the *Revised 1996 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. According to the Yearbook of Chemical Industries Statistics, beginning in 1997 there is also no production of refined methanol. The methanol refining process merely dewaters the synthesized methanol, therefore, theoretically no CH_4 is generated.

Accordingly, from 1990 to 1995, emissions are reported using the production amounts in 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 methanol given in the *Revised 1996 IPCC Guidelines* was used. The emission factor is 2 [kg-CH_4/t] (Refer to *Revised 1996 IPCC Guidelines* Vol. 2 p 2.22, Table 2-9).

- ***Activity Data***

Production amounts of methanol (on calendar year basis) given by the Methanol and Formalin Association were used as activity data for CH_4 emissions from methanol production.

Table 4-21 Methanol production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Methanol production	t	83,851	75,498	NO	NO	NO	NO	NO	NO	NO

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty is not estimated.

- ***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 methanol production have been estimated in a consistent manner throughout the time-series.

d) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

There have been no source-specific recalculations.

f) Source-specific Planned Improvements

No improvements are planned.

4.3.5.6. Coke Production (2.B.5.-)

a) Source/Sink Category Description

1) CO_2

This category is reported as "IE" because the emissions of CO_2 from coke production are included in the coal products and production section of the Fuel Combustion Sector (1.A.).

2) CH_4

CH_4 is emitted in coke production.

3) N_2O

We have no measurements of the concentration of N_2O in the gas leaking from coking furnace lids, but N_2O emissions from this source are reported as "NA," 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***

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 *Revised 1996 IPCC Guidelines*.

- ***Emission Factors***

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 4-22 Emission factor of CH_4 from coking furnace lids, desulfurization towers, and desulfurization recycling towers

Item	Unit	1990-1996	1997-1999	2000	2001	2002	2003	2004	
CH_4 EFs	kg-CH_4/t	0.238	0.180	0.119	0.062	0.052	0.042	0.055	
		2005	2006	2007	2008	2009	2010	2011	2012
		0.043	0.039	0.040	0.037	0.032	0.031	0.042	0.042

* 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***

As the activity of CH_4 emissions from coke production, the inventory used the coke production amount given in the Yearbook of Mineral Resources and Petroleum Products Statistics (previously the

Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke) compiled by the Ministry of Economy, Industry and Trade.

Table 4-23 Coke production amount

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Coke production	kt	47,338	42,279	38,511	38,009	36,551	34,140	37,036	34,875	35,024

- ***Completeness***

The Sectoral Background Data Table (Table 2(I).A-Gs2) in the CRF requires emissions of CO_2 and CH_4 from coke production to be reported as a sub-category of 2.C.1. Steel Manufacture, but coke is also manufactured in Japan in industries other than the steel industry. The emissions have therefore been counted in this category.

c) Uncertainties and Time-series Consistency

- ***Uncertainty***

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. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

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.

d) Source-specific QA/QC and Verification

See section 4.2.1. d).

e) Source-specific Recalculations

There have been no source-specific recalculations.

f) Source-specific Planned Improvements

No improvements are planned.

4.4. Metal Production (2.C.)

This category covers CO_2, CH_4, PFC and SF_6 emissions from the manufacturing processes of metal products.

This section includes GHG emissions from three sources: Iron and steel production (2.C.1.), Ferroalloys production (2.C.2.), Aluminum production (2.C.3.), and SF_6 used in aluminum and magnesium foundries (2.C.4.).

In 2012, emissions from Metal production were 391 Gg-CO_2 eq. and represented 0.03% of GHG of the Japan's total GHG emissions (excluding LULUCF). The total emissions of CO_2 and CH_4 from this category had decreased by 49.6% compared to 1990. The total of HFCs, PFCs and SF_6 had increased by 6.4% compared to 1995.

Table 4-24 Emissions from 2.C. Metal Production

Gas	Emission sub-category				Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	2.C Metal Production	2.C.1	Iron and steel production	Use of electric arc furnaces in steel production	Gg-CO_2	356.09	357.22	248.42	241.93	155.77	111.99	159.86	161.70	174.20
CH_4	2.C Metal Production	2.C.1	Iron and steel production	Use of electric arc furnaces in steel production	Gg-CH_4	0.74	0.72	0.67	0.68	0.61	0.51	0.59	0.60	0.59
		2.C.2	Ferroalloys production		Gg-CH_4	0.19	0.14	0.13	0.13	0.11	0.11	0.12	0.11	0.13
	Total				Gg-CH_4	0.92	0.85	0.80	0.80	0.72	0.62	0.71	0.72	0.72
	Total				Gg-CO_2 eq.	19.36	17.92	16.84	16.89	15.02	12.96	14.87	15.09	15.19
Total of Gases					Gg-CO_2 eq.	375.45	375.15	265.26	258.81	170.80	124.95	174.72	176.78	189.39
Gas	Emission sub-category				Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFCs	2.C Metal Production	2.C.4	SF_6 used in aluminium and magnesium foundaries		Gg-CO_2 eq.	NO	NO	NO	NO	NO	NO	NO	0.91	1.17
PFCs	2.C Metal Production	2.C.3	Aluminium production		Gg-CO_2 eq.	137.15	69.74	17.78	14.80	14.67	11.02	10.38	10.36	9.02
SF_6	2.C Metal Production	2.C.4	SF_6 used in aluminium and magnesium foundaries		t	6.43	5.00	43.00	48.42	27.30	10.00	12.88	8.00	8.00
					Gg-CO_2 eq.	153.61	119.50	1,027.70	1,157.31	652.47	239.00	307.90	191.20	191.20
Total of Gases					Gg-CO_2 eq.	290.77	189.24	1,045.48	1,172.11	667.14	250.02	318.28	202.47	201.39

4.4.1. Iron and Steel Production (2.C.1.)

4.4.1.1. Steel Production (2.C.1.-)

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.-)

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. Sinter Production (2.C.1.-)

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 “4.2.3. Limestone and Dolomite Use”.

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".

4.4.1.4. Coke Production in Iron and Steel Production (2.C.1.-)

1） CO_2

Coke is mainly produced in iron and steel production in Japan. This category is reported as "IE" because the emissions of CO_2 from coke production are included in the coal products and production section of the Fuel Combustion Sector (1.A.).

2） CH_4

Emissions of CH_4 were calculated at 4.3.5.6. Coke (2.B.5.-), and have been reported as "IE".

4.4.1.5. Use of Electric Arc Furnaces in Steel Production (2.C.1.-)

a） Source/Sink 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 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 4-25 CO_2 emissions from carbon electrodes of furnaces

	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
#A Import	t	12,341	18,463	11,363	15,075	15,116	11,218	17,321	20,436	20,027
#B Domestic production	t	211,933	186,143	184,728	216,061	201,256	169,545	205,081	217,847	197,278
#C Export	t	87,108	92,812	107,998	138,409	134,509	116,489	139,757	154,204	135,863
#D Electric furnaces gas	t	39,983	14,300	20,293	26,700	39,349	33,709	39,017	39,949	33,898
Domestic consumptions (#A + #B - #C - #D)	t	97,184	97,493	67,800	66,028	42,514	30,564	43,629	44,130	47,544
CO_2 emissions	Gg-CO_2 eq.	356	357	248	242	156	112	160	162	174

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. Solid Fuels).

- ***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, 3.2.2. and Chapter 4, 4.3.4.1)

- ***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 4-26 Energy consumption in electric arc furnaces

Electricity consumption	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Electric furnaces	TJ	57,564	55,986	52,457	52,747	47,316	39,753	45,793	47,185	46,459

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 4.5%. The uncertainty assessment methods are summarized in Annex 7.

- ***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%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

Recalculations were conducted for 2011 CH_4 emissions, since the value of the energy consumption in electric arc furnaces was updated in the General Energy Statistics.

f） Source-specific Planned Improvements

No improvements are planned.

4.4.2. Ferroalloys Production (2.C.2.)

a） Source/Sink 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 4-27 Energy consumption for ferroalloy production

Electricity consumption	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Electric furnaces (for Ferroalloys)	TJ	14,456	10,699	10,181	10,072	8,578	8,458	9,510	8,938	10,038

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%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

Recalculations were conducted for 2011 CH_4 emissions, since the value of the energy consumption in electric arc furnaces was updated in the General Energy Statistics.

f） Source-specific Planned Improvements

No improvements are planned.

4.4.3. Aluminum Production (2.C.3.)

a） Source/Sink 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） CH_4

Aluminum refining is conducted in Japan. There is a small amount of hydrogen in the pitch that acts as a raw material for the anode paste used in aluminum smelting. Theoretically, therefore, it is possible that CH_4 could be generated. As there is no actual data on emissions, however, it is not possible to calculate emissions. There is also no emission factor offered in the *Revised 1996 IPCC Guidelines*, and no data on the hydrogen content of pitch can be obtained. As it is not possible to estimate an emission factor, emissions have been reported as “NE”.

3） 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 *Revised 1996 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 1b method of the *Revised 1996 IPCC Guidelines* 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 4-28 PFC emission factors and aluminum production amounts

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
PFC-14 (CF_4)	kg-PFC-14/t	0.542	0.542	0.369	0.307	0.300	0.301	0.300	0.299	0.298
PFC-116 (C_2F_6)	kg-PFC-116/t	0.0542	0.0542	0.0369	0.0307	0.0300	0.0301	0.0300	0.0299	0.0298
Production of aluminium	t	34,100	17,338	6,500	6,490	6,600	4,930	4,670	4,670	4,075

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

- ***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), was 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 are used.

c） Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainty of the emission factor, 33% was applied, according to the *GPG (2000)* default value. For the uncertainty of the activity data, 5%, the value set by the Committee for Greenhouse Gas Estimation Methods was applied. As a result, the uncertainty of the emissions was determined to be 33%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions from 1990 to 1994 have not been estimated due to the lack of data. 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 onwards, therefore time-series consistency is taken into account to the extent possible.

d） Source-specific QA/QC and Verification

The data collected and estimated by the Manufacturing Industries Sub-Group, Ministry of Economy, Trade and Industry is verified by the Committee for Greenhouse Gas Estimation Methods and is used in the inventory.

e） Source-specific Recalculations

PFC emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.4.4. SF_6 Used in Aluminum and Magnesium Foundries (2.C.4.)

4.4.4.1. Aluminum Foundry

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.

4.4.4.2. Magnesium Foundry

a） Source/Sink Category Description

SF_6 and HFCs are emitted in magnesium foundries, due to its use as cover gas to prevent oxidation of molten magnesium. HFC emissions are reported under 2.C.5. Other in the CRF.

b） Methodological Issues

Emissions are an aggregation of all SF_6 and HFCs 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 SF_6 and HFCs used in magnesium foundries. The associated indices are given in the table below.

Table 4-29 Indices related to SF_6 emitted from magnesium foundries

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Consumption of SF_6	t	6.4	5.0	43.0	48.4	27.3	10.0	12.9	8.0	8.0

Source: 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 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***

For the uncertainty of the emission factor, 0% was applied, due to the fact that the amount of emissions is equal to the amount of magnesium used. For the uncertainty of the activity data, 5% was applied, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainty of the emissions was determined to be 5%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

HFC emissions were newly identified, therefore recalculations were conducted for 2011. Additionally, SF_6 emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.5. Other Production (2.D.)

4.5.1. Pulp and Paper (2.D.1.)

Pulp and Paper production possibly emit nitrogen oxides (NO_X), carbon monoxide (CO), non-CH_4 volatile organic compounds (NMVOC), and sulfur dioxide (SO_2). These emissions are reported in Annex 3.

4.5.2. Food and Drink (2.D.2.)

Foods and drinks are manufactured in Japan, and because CO_2 is used in the manufacturing process (frozen CO_2 and raw material for carbonated drinks, etc.), it is conceivable that CO_2 is emitted into the atmosphere in the course of manufacturing. The CO_2 used in the process of manufacturing foods and drinks, however, is a by-product gas of petrochemical products, and as such emissions have already been incorporated into the Fuel combustion sector (1.A.), they have been reported as “IE”.

4.6. Production of Halocarbons and SF_6 (2.E.)

This category covers HFC, PFC and SF_6 emissions from the manufacturing processes of Halocarbons and SF_6.

This section includes GHG emissions from two sources: By-product emissions: production of HCFC-22 (2.E.1.) and Fugitive emissions (2.E.2.).

In 2012, emissions from Production of Halocarbons and SF_6 were 344 Gg-CO_2 eq. and represented 0.03% of GHG of Japan’s total GHG emissions (excluding LULUCF). The emissions had decreased by 98.5% compared to 1995.

Table 4-30 Emissions from 2.E. Production of Halocarbons and SF_6

Gas	Emission sub-category			Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFCs	2.E Production of Halocarbons and SF_6	2.E.1	By-product emissions: Production of HCFC-22	Gg-CO_2 eq.	12,592.30	16,965.00	12,402.00	463.32	469.17	39.78	42.12	12.87	14.04
		2.E.2	Fugitive emissions	Gg-CO_2 eq.	1.30	480.12	257.84	352.69	232.83	182.36	86.22	99.65	78.38
	Total			Gg-CO_2 eq.	12,593.60	17,445.12	12,659.84	816.01	702.00	222.14	128.34	112.52	92.42
PFCs	2.E Production of Halocarbons and SF_6	2.E.2	Fugitive emissions	Gg-CO_2 eq.	276.08	762.85	1,359.00	837.49	523.80	399.48	200.24	171.90	122.16
SF_6		2.E.2	Fugitive emissions	t	152.23	197.00	36.00	40.80	53.90	10.90	8.30	5.80	5.40
				Gg-CO_2 eq.	3,638.23	4,708.30	860.40	975.12	1,288.21	260.51	198.37	138.62	129.06
Total of All Gases				Gg-CO_2 eq.	16,507.91	22,916.27	14,879.24	2,628.62	2,514.01	882.13	526.96	423.05	343.64

4.6.1. By-product Emissions: Production of HCFC-22 (2.E.1.)

a） Source/Sink 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 4-31 Indices related to By-product Emissions of HFC-23: Production of HCFC-22

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Production of HCFC-22	t	60,122	81,000	95,271	65,715	60,401	26,682	46,149	45,314	54,388
Rate of generation of HFC-23	%	2.13%	2.13%	1.70%	1.90%	2.00%	2.34%	2.01%	1.53%	1.60%
Emission rate to production of HCFC-22	%	1.79%	1.79%	1.11%	0.06%	0.07%	0.01%	0.01%	0.002%	0.002%
Emissions	t	1,076	1,450	1,060	40	40	3	4	1	1
	Mt-CO_2 eq.	12.59	16.97	12.40	0.46	0.47	0.04	0.04	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

* 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[3], 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 emission factor, 2% was applied, according to the *IPCC 2006 Guidelines* default value. For the uncertainty of the activity data, 5% was applied, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainty of the emissions was determined to be 5%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c).

d) Source-specific QA/QC and Verification

See section 4.4.3. d). 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) Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994.

f) Source-specific Planned Improvements

No improvements are planned.

4.6.2. Fugitive Emissions (2.E.2.)

a) Source/Sink Category Description

HFCs, PFCs, SF_6 are emitted as fugitive emissions during their manufacturing. Regarding returned gas cylinders, for decomposition of the residual gases and cleansing of the containment shell, or releasement 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 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.

[3] MITI Documents of the first meeting of the Group for global warming chemicals, Risk Management Sub-Group, Chemicals Council, 1997.

The associated indices are given in the table below.

Table 4-32 Fugitive emissions from HFC production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Emissions	Mt-CO_2 eq.	0.0013	0.4801	0.2578	0.3527	0.2328	0.1824	0.0862	0.0997	0.0784

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 4-33 Indices related to fugitive emissions from PFC production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Production of PFCs	t	437	1,207	2,336	2,726	2,802	2,028	2,800	2,670	2,446
Emissions	t	39	107	181	107	67	50	25	24	16
	Mt-CO_2 eq.	0.276	0.763	1.359	0.837	0.524	0.399	0.200	0.172	0.122

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 4-34 Indices related to fugitive emissions from SF_6 production

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Production of SF_6	t	1,848	2,392	1,556	2,313	2,647	2,562	2,201	1,993	2,230
Emissions	t	152.2	197.0	36.0	40.8	53.9	10.9	8.3	5.8	5.4
	Mt-CO_2 eq.	3.638	4.708	0.860	0.975	1.288	0.261	0.198	0.139	0.129

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.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using HFC, PFC, and SF_6 shipment amounts[4] which is thought to be proportional to HFC, PFC, and SF_6 production amounts, and the ratio of emissions to the HFC, PFC, and SF_6 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 emission factors, 100% was applied for all HFCs, PFCs, and SF_6, according to the *GPG (2000)* default value. For the uncertainties of the activity data, 10% was

[4] 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.

applied for all HFCs, PFCs and SF_6, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions for all HFCs, PFCs and SF_6 were determined to be 100%.　The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

More accurate information became available on HFC emissions for 2008 and 2011, resulting in recalculations. Additionally, HFC, PFC, and SF_6 emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.7. Consumption of Halocarbons and SF_6 (2.F.)

This category covers HFC, PFC and SF_6 emissions from the manufacturing, utilization and disposal processes of the products of Halocarbons and SF6 used. This section includes GHG emissions from nine sources: Refrigeration and air conditioning equipment (2.F.1.), Foam blowing (2.F.2.), Fire extinguishers (2.F.3.), Aerosols (2.F.4.) Solvents (2.F.5.), Other applications using ODS substitutes (2.F.6.), Semiconductors (2.F.7.), Electrical equipment (2.F.8.) and Other (2.F.9.).

In 2012, emissions from Consumption of halocarbons and SF_6 were 26,724 Gg-CO_2 eq., and represented 2.0% of GHG of Japan's total GHG emissions (excluding LULUCF). The emissions had decreased by 5.9% compared to 1995.

Table 4-35 Emissions from 2.F. Consumption of Halocarbons and SF_6

Gas	Emission sub-category			Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFCs	2.F Consumption of Halocarbons and SF_6	2.F.1	Refrigeration and air conditioning equipment	Gg-CO_2 eq.	NO	840.40	2,688.60	7,667.03	13,268.94	15,126.13	17,123.07	19,338.84	21,920.35
		2.F.2	Foam blowing	Gg-CO_2 eq.	1.22	451.76	440.31	316.30	286.38	290.18	290.97	294.70	294.47
		2.F.3	Fire extinguishers	Gg-CO_2 eq.	NO	NO	3.73	5.92	6.35	6.55	6.72	6.82	7.01
		2.F.4	Aerosols/Metered dose inhalers	Gg-CO_2 eq.	NO	1,365.00	2,834.35	1,571.89	889.55	809.25	640.09	608.72	534.47
		2.F.7	Semiconductors	Gg-CO_2 eq.	0.43	157.89	173.60	141.06	145.68	92.36	102.19	89.02	75.81
	Total			Gg-CO_2 eq.	1.65	2,815.05	6,140.59	9,702.21	14,596.89	16,324.46	18,163.04	20,338.10	22,832.09
PFCs	2.F Consumption of Halocarbons and SF6	2.F.5	Solvents	Gg-CO_2 eq.	3,725.57	10,294.33	2,569.49	2,277.69	1,318.27	1,137.07	1,375.99	1,284.23	1,266.47
		2.F.7	Semiconductors	Gg-CO_2 eq.	1,137.91	3,144.23	5,637.07	3,860.52	2,756.49	1,715.19	1,818.65	1,545.14	1,360.63
		2.F.9	Other-Railway silicon rectifiers	Gg-CO_2 eq.	NO	NO	NO	0.23	1.84	2.49	3.45	4.72	NO
	Total			Gg-CO_2 eq.	4,863.48	13,438.56	8,206.56	6,138.44	4,076.60	2,854.75	3,198.08	2,834.09	2,627.09
SF_6	2.F Consumption of Halocarbons and SF6	2.F.7	Semiconductors	t	36.49	47.22	94.16	72.50	39.85	25.37	29.45	23.74	21.39
		2.F.8	Electrical equipment	t	355.81	460.46	127.62	39.45	36.32	31.19	27.29	30.99	31.53
	Total			t	392.30	507.68	221.77	111.95	76.17	56.56	56.74	54.73	52.92
	Total			Gg-CO_2 eq.	9,376.00	12,133.65	5,300.39	2,675.51	1,820.54	1,351.76	1,356.15	1,308.03	1,264.83
Total of All Gases				Gg-CO_2 eq.	14,241.13	28,387.26	19,647.55	18,516.16	20,494.02	20,530.98	22,717.28	24,480.22	26,724.02

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） Source/Sink 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 4-36 Indices related to emissions of HFCs from domestic refrigeration

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total HFCs charged in the year of production	t	NO	520	590	0.3	NO	NO	NO	NO	NO
Fugitive refrigerant ratio at production	%	1.00%	1.00%	1.00%	0.17%	NO	NO	NO	NO	NO
Number of operated HFC devices	1,000 devices	NO	7,829	33,213	41,796	34,509	31,471	28,085	24,509	20,984
Refrigerant charged per device at production	g	150	150	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%
Number of HFC devices disposed	1,000 devices	NO	NO	176.8	1839.2	3153.8	3444.6	3588.1	3600.4	3455.9
Amount of HFCs collected under law	t/year	—	—	—	51.653	110.75	139	167	160	169
Emissions	t	NO	8.7	40.1	187.8	283.9	289.0	276.3	282.7	254.2
	Mt-CO_2 eq.	NO	0.0113	0.0521	0.2442	0.3691	0.3757	0.3592	0.3675	0.3305

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, 50% was applied for all production, use, and disposal, according to the values used in a similar category. For the uncertainties of the activity data, 40% was applied for all production, use, and disposal, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions for all production, use, and disposal were determined to be 64%. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

See section 4.4.3. c).

d) Source-specific QA/QC and Verification

See section 4.4.3. d).

e) Source-specific Recalculations

More accurate information became available on the number of operated HFC devices for 2010, resulting in recalculations. Additionally, emissions were newly estimated for the years 1990 to 1994.

f） Source-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） Source/Sink 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 conducted using a model, by taking into account the type of device and year of production etc, and based on the principles of the GPG. 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[5]. (260,000 sample units, conducted from 2007 to 2009. Emission factors are country-specific.

> *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

[5] 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 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 4-37 Indices related to emissions of HFCs from commercial refrigeration

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of HFC devices produced	1,000 devices	NO	214	374	1,413	1,444	987	1,122	1,198	1,212
Average amount of refrigerant charged at production	g/device	372	372	597	3,378	3,533	3,276	3,280	3,360	3,462
Fugitive refrigerant ratio at production	%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%	0.2%	0.2%
Number of devices charged in production place	1,000 devices	NO	9	32	138	199	175	171	190	239
Average amount of refrigerant during installation	g/device	17,806	17,806	9,221	23,914	26,529	25,361	23,766	23,714	22,319
Fugitive refrigerant ratio during installation	%	1.2%	1.2%	1.4%	1.8%	1.7%	1.6%	1.6%	1.6%	1.6%
Number of devices operated	1,000 devices	NO	375	1,957	6,770	10,027	10,847	11,743	12,678	13,616
Amount of refrigerant during operation	g/device	1,012	1,012	1,043	4,549	5,629	5,791	5,961	6,155	6,411
Fugitive refrigerant ratio during use	%	2-17% (depending on the kind of device)								
Number of devices disposed	1,000 devices	NO	1	23	127	269	325	397	453	512
Amount of HFCs collected under law during maintenance	t	NO	NO	NO	NO	436	503	548	571	671
Amount of HFCs collected under law after use	t	NO	NO	NO	183	200	230	269	352	522
Emissions from manufacturing	Mt-CO_2 eq.	NO	0.003	0.008	0.126	0.195	0.168	0.164	0.182	0.223
Emissions from stocks	Mt-CO_2 eq.	NO	0.036	0.229	2.900	6.432	7.582	8.814	10.230	11.883
Emissions from disposal	Mt-CO_2 eq.	NO	0.003	0.046	0.501	1.630	1.995	2.333	2.635	2.904
Emissions	Mt-CO_2 eq.	NO	0.042	0.283	3.527	8.258	9.746	11.311	13.047	15.010

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 4-38 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***

See section 4.7.1.1. c）.

- ***Time-series Consistency***

See section 4.4.3. 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）Source-specific QA/QC and Verification

See section 4.4.3. d）.

e）Source-specific Recalculations

More accurate information became available on the average amount of refrigerant during installation, and amount of refrigerant during operation for 2011, resulting in recalculations. Additionally, emissions were newly estimated for the years 1990 to 1994.

f）Source-specific Planned Improvements

No improvements are planned.

4.7.1.2.b. Automatic Vending machine Production, Use and Disposal

a）Source/Sink 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 machine

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 4-39 Indices related to emissions of HFCs from automatic vending machines

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of HFC devices produced	1,000 devices	NO	NO	272	355	270	173	173	124	30
Refrigerant charged per device	g	NO	NO	300	220	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%
Number of devices operated	1,000 devices	NO	NO	284	1,999	2,384	2,368	2,279	2,055	1,759
Incidence rate	%	NO	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Fugitive refrigerant ratio (failure)	%	NO	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%
Fugitive refrigerant ratio (fixing)	%	NO	0.9%	0.9%	0.5%	0.4%	0.4%	0.4%	0.4%	0.4%
Number of devices disposed	1,000 devices	NO	NO	NO	NO	213	293	286	347	277
Emissions	t	NO	NO	0.4	0.6	12.4	16.8	16.4	9.5	0.3
	Mt-CO_2 eq.	NO	NO	0.0006	0.0009	0.0190	0.0257	0.0250	0.0145	0.0004

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, 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, 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 4.7.1.1. c).

- ***Time-series Consistency***

See section 4.4.3. c).

d）Source-specific QA/QC and Verification

See section 4.4.3. d）.

e）Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f）Source-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. 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）Source/Sink 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.

<u>*Emissions of HFCs from Stationary Air-Conditioning (Household)*</u>

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 4-40 Indices related to emissions of HFCs from stationary air-conditioning (household)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of HFC devices produced	1,000 devices	NO	NO	1,077	3,981	3,970	2,618	3,169	3,155	3,263
Refrigerant charged per device	g	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%
Number of devices operated	1,000 devices	NO	NO	1,726	26,091	47,584	53,966	61,540	68,769	75,833
Average refrigerant charged during use	g/device	NO	NO	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%
Number of devices disposed	1,000	NO	NO	2	83	351	524	764	1,075	1,456
Average refrigerant stock in device disposed	g/device	NO	NO	954	911	870	856	841	827	814
Amount of HFCs collected under law	t/year	-	-	-	10	67	122	231	264	322
Emissions	t	NO	NO	38	596	1,206	1,426	1,675	2,014	2,400
	Mt-CO_2 eq.	NO	NO	0.066	1.029	2.080	2.460	2.890	3.474	4.138

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, 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 4.7.1.1. c）.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f） Source-specific Planned Improvements

No improvements are planned.

4.7.1.6. Mobile Air-Conditioning (Car Air Conditioners) Production, Use and Disposal (2.F.1.-)

a） Source/Sink 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 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.”

Table 4-41 Indices related to emissions of HFC-134a from car air conditioners

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Number of cars produced	1,000 devices	0	9,745	9,761	10,407	11,163	7,653	9,292	8,136	9,856
Fugitive refrigirant during production	g	4	4	4	3	3	1	1	1	1
Number of cars operated with HFC air conditioners	1,000 devices	0	15,655	42,374	60,364	64,543	65,375	66,043	67,366	68,956
Average refrigerant charged per device	g	700	700	615	548	520	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
Rate of breakdown incidences	%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Fugitive refrigerant ratio from breakdown cars	%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Number of cars completely destroyed	1,000 devices	0	50	136	193	207	209	211	216	221
Average refrigerant charged in completely destroyed cars	g	681	681	610	522	475	461	448	439	426
Number of cars disposed	1,000 devices	0	116	789	2,058	2,176	2,498	2,895	2,235	2,709
Average refrigerant charged at time of disposal	g	676	676	593	522	466	456	444	427	404
Amount of HFC collected (under law from FY2002)	t/year	-	-	-	531	686	787	898	645	786
Emissions	t	0	605	1,759	2,205	1,956	1,938	1,952	1,874	1,878
	Mt-CO_2 eq.	0.000	0.787	2.287	2.866	2.543	2.520	2.537	2.436	2.441

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 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 4.7.1.1. c）.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

More accurate information became available on the number of cars operated with HFC air conditioners, number of cars completely destroyed, average refrigerant charged in completely destroyed cars, and average refrigerant charged at time of disposal, resulting in recalculations for 2009 to 2011. Additionally, emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.7.2. Foam Blowing (2.F.2.)

4.7.2.1. Hard Foam Production (2.F.2.-)

4.7.2.1.a. Urethane Foam

a） Source/Sink Category Description

HFC-134a is 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-134a emissions*
> HFC-134a emissions
> = Amount of HFC-134a 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 4-42 Indices related to emissions of HFC-134a from urethane foam

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC-134a use	t	NO	NO	167	224	145	109	66	65	34
Leakage during foam blowing	%	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%
Emissions within the first year after production	t	NO	NO	17	35	15	11	7	7	3
Emissions during use	t	NO	NO	NO	44	75	82	86	89	92
Emissions	t	NO	NO	16.7	78.8	89.5	92.4	93.0	95.9	95.7
Emissions during production	Mt-CO_2 eq.	NO	NO	0.022	0.046	0.019	0.014	0.009	0.008	0.004
Emissions during use	Mt-CO_2 eq.	NO	NO	NO	0.057	0.098	0.106	0.112	0.116	0.120
Emissions	Mt-CO_2 eq.	NO	NO	0.022	0.102	0.116	0.120	0.121	0.125	0.124

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, 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 emission factors, 50% was applied for both production and use, according to the values used in a similar category. For the uncertainties of the activity data, 50% was applied for both production and use, according to *GPG (2000)*’s default value. As a result, the uncertainties of the emissions for both production and use were determined to be 71%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c).

d) Source-specific QA/QC and Verification

See section 4.4.3. d).

e) Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f) Source-specific Planned Improvements

No improvements are planned.

4.7.2.1.b. High Expanded Polyethylene Foam (2.F.2.-)

a) Source/Sink Category Description

HFC-134a 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 4-43 Indices related to emissions of HFC-134a from high expanded polyethylene foam

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC-134a use	t	1	346	322	128	100	100	100	100	100
Emissions	t	1	346	322	128	100	100	100	100	100
	Mt-CO_2 eq.	0.001	0.450	0.419	0.166	0.130	0.130	0.130	0.130	0.130

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 4-44 Indices related to emissions of HFC-152a from high expanded polyethylene foam

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC-152a use	t	0.038	14	NO	NO	NO	NO	NO	NO	NO
Emissions	t	0.038	14	NO	NO	NO	NO	NO	NO	NO
	Mt-CO_2 eq.	0.000005	0.00196	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 4.4.3. c）.

d）Source-specific QA/QC and Verification

See section 4.4.3. d）.

e）Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994.

f）Source-specific Planned Improvements

No improvements are planned.

4.7.2.1.c. Extruded Polystyrene Foam Production (2.F.2.-)

a）Source/Sink 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 over 30 years at the rate of 2.5% 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 IPCC Good Practice Guidance 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 4-45 Indices related to emissions of HFC-134a from extruded polystyrene foam

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
HFC-134a use	t	NO	NO	NO	26	NO	NO	NO	NO	NO
Foam productization rate	%	-	-	-	75%	75%	75%	75%	75%	75%
Annual emission rate during use	%	-	-	-	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
Emissions during production	t	NO	NO	NO	6.50	NO	NO	NO	NO	NO
Emissions during use	t	NO	NO	NO	30.00	30.78	30.78	30.78	30.78	30.78
Emissions	t	NO	NO	NO	36.50	30.78	30.78	30.78	30.78	30.78
Emissions during production	Mt-CO_2 eq.	NO	NO	NO	0.01	NO	NO	NO	NO	NO
Emission during use	Mt-CO_2 eq.	NO	NO	NO	0.04	0.04	0.04	0.04	0.04	0.04
Emissions	Mt-CO_2 eq.	NO	NO	NO	0.05	0.04	0.04	0.04	0.04	0.04

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, 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 4.4.3. c).

d) Source-specific QA/QC and Verification

See section 4.4.3. d).

e) Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f) Source-specific Planned Improvements

No improvements are planned.

4.7.2.2. Soft Foam (2.F.2.-)

All foam using HFCs for forming is hard foam. Emissions have therefore been reported as “NO”.

4.7.3. Fire Extinguishers (2.F.3.)

a） Source/Sink 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 equipments, 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, 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.

<u>*HFC emissions from use of fire extinguishers*</u>

HFC emissions [t] ＝ HFC extinguishing agent installations and stocks [t] × 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, 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 4-46 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 4-47 The amounts of the HFC extinguishing agent installations and stocks

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Installations and stocks of HFC-23	t	NO	NO	306	478	501	512	523	528	533
HFC-23 emissions	t	NO	NO	0.27	0.42	0.44	0.45	0.46	0.46	0.47
	Gg-CO_2 eq.	NO	NO	3.15	4.92	5.16	5.27	5.39	5.43	5.48
Installations and stocks of HFC-227ea	t	NO	NO	225	392	467	498	522	544	596
HFC-227ea emissions	t	NO	NO	0.20	0.34	0.41	0.44	0.46	0.48	0.52
	Gg-CO_2 eq.	NO	NO	0.57	1.00	1.19	1.27	1.33	1.39	1.52
Total emissions	Gg-CO_2 eq.	NO	NO	3.73	5.92	6.35	6.55	6.72	6.82	7.01

c） Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factor for fire extinguisher use, 50% was applied, according to the values used in a similar category. For the uncertainties of the activity data, 40% was applied according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions during use for the category were determined to be 64%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

The data received from the Fire Defense Agency is compiled by the Manufacturing Industries Sub-Group, Ministry of Economy, Trade and Industry. It is verified by the Committee for Greenhouse Gas Estimation Methods and is used in the inventory.

e） Source-specific Recalculations

HFC emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f） Source-specific Planned Improvements

No improvements are planned.

4.7.4. Aerosols (2.F.4.)

4.7.4.1. Aerosols (2.F.4.-)

a） Source/Sink Category Description

HFCs are emitted from the manufacturing and use of aerosols.

b） Methodological Issues

- ***Estimation Method***

In accordance with the 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.

F-gas (HFC-134a, HFC-152a) emissions associated with the manufacturing of Aerosol

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 (%)

Fugitive emissions during manufacturing = F-gas consumed during manufacturing in year n
- F-gas potential emissions

The associated indices are given in the table below.

Table 4-48 Indices related to emissions of HFC-134a from aerosols

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Potential emissions	t	NO	1,300	2,044	604	343	230	200	190	168
Fugitive emissions during production	t	-	-	80.2	24.9	12.8	10.0	8.1	7.0	8.3
Emissions in the year produced, during use	t	NO	650	1,022	302	172	115	100	95	84
Remaining (emissions in the next year)	t	NO	650	1,022	302	172	115	100	95	84
Emissions	t	NO	1,050	2,137	908	338	297	223	202	187
	Mt-CO_2 eq.	NO	1.365	2.778	1.181	0.439	0.386	0.290	0.263	0.243

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 4-49 Indices related to emissions of HFC-152a from aerosols

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Potential emissions	t	NO	NO	34.1	1,300	1,416	764	558	502	542
Fugitive emissions during production	t	NO	NO	1.1	28.9	381	494	638	730	464
Emissions in the year produced, during use	t	NO	NO	17.1	650	708	382	279	251	271
Remaining (emissions in the next year)	t	NO	NO	17.1	650	708	382	279	251	271
Emissions	t	NO	NO	18.2	1,217	1,685	1,584	1,299	1,260	986
	Mt-CO_2 eq.	NO	NO	0.003	0.170	0.236	0.222	0.182	0.176	0.138

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.

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 is 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, 40% was applied for all production, use, and disposal, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions for all production, use and disposal were determined to be 40%. The uncertainty assessment

methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

Emissions were newly estimated for the years 1990 to 1994. (However, HFC-152a emissions are NO for all of these years.)

f） Source-specific Planned Improvements

No improvements are planned.

4.7.4.2. Metered Dose Inhalers (2.F.4.-)

a） Source/Sink 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 4-50 Indices related to emissions of HFC-134a from MDI

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Purchases of F-gas	t	NO	NO	1.40	1.10	1.05	0.91	1.07	0.89	0.86
Usage of domestic MDI	t	NO	NO	1.40	0.90	0.88	0.91	1.07	0.79	0.77
Usage of imported MDI	t	NO	NO	42.0	70.7	61.9	57.1	57.1	54.0	48.3
Amount collected and destroyed	t	NO	NO	0.10	1.90	0.48	0.42	2.52	2.41	0.76
Emissions	t	NO	NO	37.2	62.8	61.2	60.0	55.5	54.1	51.3
	Mt-CO_2 eq.	NO	NO	0.048	0.082	0.080	0.078	0.072	0.070	0.067

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 4-51 Indices related to emissions of HFC-227ea from MDI

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Purchases of F-gas	t	NO	NO	NO	42.8	48.0	29.3	37.0	32.0	27.3
Usage of domestic MDI	t	NO	NO	NO	41.0	45.9	27.8	36.0	30.9	25.8
Usage of imported MDI	t	NO	NO	3.60	2.10	9.00	1.58	0.42	0.77	0.73
Amount collected and destroyed	t	NO	NO	NO	1.20	1.55	0.86	0.80	0.86	0.80
Emissions	t	NO	NO	1.8	48.1	46.4	42.8	33.1	34.3	29.8
	Mt-CO_2 eq.	NO	NO	0.005	0.139	0.135	0.124	0.096	0.099	0.086

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, 40% was applied for all production, use and disposal, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions for all production, use and disposal were determined to be 40%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

Emissions were newly estimated for the years 1990 to 1994. (However, emissions are NO for all of these years.)

f) Source-specific Planned Improvements

No improvements are planned.

4.7.5. Solvents (2.F.5.)

a) Source/Sink Category Description

HFCs and PFCs are emitted from the use of solvents. The liquids PFCs used were C_5F_{12} (PFC-41-12) and C_6F_{14} (PFC-51-14). HFCs used as solvents correspond to confidential data; therefore, these data are reported as included numbers in the total of PFCs.

b) Methodological Issues

- ***Estimation Method***

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.F.9. for details) are subtracted from liquid PFC emissions to yield the total PFC emissions.

Table 4-52 PFC emissions from solvents use

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
PFC emissions from solvents	Gg-CO_2 eq.	3725.6	10294.3	2569.5	2277.7	1318.3	1137.1	1376.0	1284.2	1266.5

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

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 emission factors, 0% was applied for solvent use, due to the fact that the amount of emissions is equal to the amount of solvent used. For the uncertainties of the activity data, 40% was applied for solvent using according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions were determined to be 40%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated in a manner consistent over the time-series methodologically and from the point of view of data source.

d) Source-specific QA/QC and Verification

See section 4.4.3. d).

e) Source-specific Recalculations

More accurate information became available on PFC emissions for 2011, resulting in recalculations. Additionally, emissions were newly estimated for the years 1990 to 1994.

f) Source-specific Planned Improvements

No improvements are planned.

4.7.6. Other applications using ODS substitutes (2.F.6.)

Refrigerants filled in research and medical equipment are captured and included in other refrigerant categories, therefore the emissions from this category is reported as "IE", based on expert judgment.

4.7.7. Semiconductors Manufacture (2.F.7.)

4.7.7.1. Semiconductors (2.F.7.-)

a) Source/Sink Category Description

HFCs, PFCs and SF_6, are emitted from the manufacturing of semiconductors.

b) Methodological Issues

- ***Estimation Method***

Methods of emissions from semiconductors are in line with the IPCC *GPG (2000)*. 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. Emission factors are country-specific.
In addition, regarding the treatment of 10% as residue of process supply rate, these emissions are reported in this category in case of a 90% recharging rate and subsequent shipment. In cases of decomposing the residual 10% and cleansing the containment shell, or releasement into the atmosphere, these emissions are reported in “2.E.2. Production of Halocarbons and SF_6”.
Japan Electronics and Information Technology Industries Association data are used for F-gases purchased.

Emissions from manufacturing are reported as “IE” for this category. Theoretically, emissions from disposal cannot be generated, therefore are reported as “NA”.

<u>F-gas emissions in Semiconductor Manufacturing</u>

Methods below are applied for each F-gas:

(i) HFC-23, PFCs (PFC-14, PFC-116, PFC-218, PFC-c318), SF_6 emissions

Emissions
= Total CO_2 equivalent emissions from all production lines
- Total CO_2 equivalent amount destroyed in all production lines

Total CO_2 equivalent emissions from all production lines
$= \Sigma$ each production line Σ {amount purchased per F-gas × process supply rate × (1 - use rate of F-gas) × GWP}

Total CO_2 equivalent amount destroyed in all production lines
$= \Sigma$ each production line Σ {amount purchased per F-gas × process supply rate × (1 - use rate of F-gas) × fraction of F-gas destroyed × GWP}

(For production lines without destruction facilities: fraction of F-gas destroyed = 0)

(ii) By-produced PFC-14 emissions

Emissions
= Total CO_2 equivalent emissions from all production lines
- Total CO_2 equivalent amount destroyed in all production lines

Total CO_2 equivalent emissions from all production lines
$= \Sigma$ each production line Σ (purchases of PFCs × process supply rate × by production rate × GWP)

Total CO_2 equivalent amount destroyed in all production lines
$= \Sigma$ each production line Σ (purchases of PFCs × process supply rate × by production rate × fraction of F-gas destroyed × GWP)

(For production lines without destruction facilities: fraction of F-gas destroyed = 0)

Relevant indices are shown in Table below.

Table 4-53 Indices related to emissions of F-gases from manufacturing of semiconductors

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
PFC-14 purchased	t	113.3	313.0	299.9	231.5	276.9	208.9	265.3	248.3	222.4
PFC-116 purchased	t	75.8	209.5	561.2	393.2	284.9	171.5	194.3	159.9	139.4
PFC-218 purchased	t	0.01	0.03	9.91	181.8	181.0	129.5	167.0	137.0	115.5
PFC-c318 purchased	t	0.90	0.63	38.6	24.8	40.2	33.3	35.8	36.8	39.7
HFC-23 purchased	t	0.1	47.8	49.4	42.1	73.7	53.8	67.1	68.4	66.7
SF_6 purchased	t	70.1	90.8	131.9	96.8	79.1	60.2	76.7	65.2	63.7
Process supply rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Use rate of PFC etc	%	20 -70% (depending on the substance)								
Fraction of PFCs etc destroyed	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
CF_4 by-production rate	%		C_2F_6 (PFC-116): 10%, C_3F_8 (PFC-218): 20%							
By-product CF_4 removal rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
HFC emissions	Mt-CO_2 eq.	0.00043	0.158	0.172	0.138	0.142	0.090	0.099	0.085	0.073
PFC emissions	Mt-CO_2 eq.	1.102	3.046	5.409	3.712	2.665	1.672	1.765	1.477	1.281
SF_6 emissions	Mt-CO_2 eq.	0.777	1.005	1.484	1.111	0.694	0.433	0.469	0.395	0.361

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 4-54 Use rate of HFCs, PFCs, and SF_6 during semiconductor manufacturing

Gas	Use rate
PFC-14	20%
PFC-116	30%
PFC-218	60%
PFC-c318	70%
HFC-23	70%
SF_6	50%

*: use rates are default values from the IPCC guidelines.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic HFC, PFC, and SF_6 shipment amounts which is thought to be proportional to HFC, PFC, and SF_6 emissions, and extrapolating for these years.

c） Uncertainties and Time-series Consistency

- ***Uncertainty***

For the uncertainties of the emission factors, 50% was applied for all HFCs, PFCs and SF_6, according to the values used in a similar category. For the uncertainties of the activity data, 40% was applied for all HFCs, PFCs and SF_6, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainties of the emissions for all HFCs, PFCs and SF_6 were determined to be 64%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

More accurate information became available on PFC emissions for 2010, resulting in recalculations. Additionally, emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.7.7.2. Liquid Crystals (2.F.7.-)

a） Source/Sink Category Description

HFCs, PFCs and SF_6, 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. Emission factors are 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, it should be applied IPCC methods.

Table 4-55 Indices related to emissions of F-gases from manufacturing of liquid crystals

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
PFC-14 purchased	t	7.5	20.7	47.3	77.8	69.3	51.9	93.7	124.3	121.1
PFC-116 purchased	t	0.1	0.4	2.7	9.9	4.1	2.3	NO	NO	NO
PFC-c318 purchased	t	NO	NO	NO	0.8	1.9	1.7	1.6	1.9	1.7
HFC-23 purchased	t	0.00027	0.1	0.7	1.6	1.5	1.1	1.1	1.2	1.0
SF_6 purchased	t	8.9	11.5	85.3	101.4	146.8	127.1	176.9	129.0	104.1
Process supply rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Use rate of PFCs etc	%	20 -70% (depending on the substance)								
Fraction of PFCs etc destroyed	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
CF_4 by-production rate	%	C_2F_6 (PFC-116): 10%								
By-product CF_4 removal rate	%	90%	90%	90%	90%	90%	90%	90%	90%	90%
HFC emissions	Mt-CO_2 eq.	0.000001	0.000316	0.001929	0.003483	0.003260	0.002577	0.003446	0.003752	0.002732
PFC emissions	Mt-CO_2 eq.	0.036	0.099	0.228	0.149	0.092	0.043	0.053	0.068	0.079
SF_6 emissions	Mt-CO_2 eq.	0.096	0.124	0.766	0.622	0.259	0.174	0.235	0.172	0.150

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
*Fractions of F-gas destroyed are default values from the IPCC guidelines.

Due to the lack of data necessary to estimate emissions for the years 1990 to 1994, estimates have been done by using domestic HFC, PFC, and SF_6 shipment amounts which is thought to be proportional to HFC, PFC, and SF_6 emissions, and extrapolating for these years.

c） Uncertainties and Time-series Consistency

- ***Uncertainty***

See section 4.7.7.1. c).

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

Emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.7.8. Electrical Equipment (2.F.8.)

a） Source/Sink 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.

<u>SF_6 emissions from the production of electrical equipment</u>

SF_6 Emissions from the production ＝ SF_6 purchased（t）× assembly fugitive rate（%）

<u>SF_6 emission from the use of electrical equipment</u>

SF_6 emission from the use

＝ Stocks of SF_6 × rate of emitted SF_6 into the environment during the use of electrical equipments (0.1%)

<u>SF_6 emission from the inspection of electrical equipment</u>

SF_6 emission from the inspection ＝ actual measurements of SF_6

<u>SF_6 emission from the disposal of electrical equipment</u>

SF_6 emission from the disposal ＝ actual measurements of SF_6

The associated indices are given in the table below.

Table 4-56 Indices related to emissions of SF_6 from electrical equipment assembly

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
SF_6 purchased	t	1,066	1,380	649	629	784	459	315	394	315
SF_6 charged to electrical equipment	t	1,464	1,464	450	582	726	410	282	352	331
Assembly fugitive rate	%	29%	29%	15%	3%	2%	2%	2%	2%	2%
Emissions	t	309	400	100	23	19	11	7	7	6
	Mt-CO_2 eq.	7.387	9.560	2.402	0.548	0.444	0.263	0.165	0.177	0.153

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 4-57 Indices related to emissions of SF_6 during the use of electrical equipment

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Stocks of SF_6	t	4,868	6,300	8,000	8,700	9,000	9,000	9,100	9,200	9,300
Operational fugitive rate	%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
SF_6 emissions during use, maintenance, and disposal	t	46.72	60.46	27.13	16.51	17.75	20.19	20.39	23.59	25.13
	Gg-CO_2 eq.	1116.59	1444.99	648.36	394.48	424.19	482.56	487.34	563.82	600.62

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 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% was applied for production, and 50% was applied for use and disposal, according to the *GPG (2000)*'s default value. For the uncertainties of the activity data, 40% was applied for all production, use and disposal, according to the value set by the Committee for Greenhouse Gas Estimation Methods. As a result, the uncertainty of the emissions for production was determined to be 50%, and 64% for use and disposal. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

See section 4.4.3. c）.

d） Source-specific QA/QC and Verification

See section 4.4.3. d）.

e） Source-specific Recalculations

More accurate information became available on SF_6 emissions for 2008, resulting in recalculations. Additionally, emissions were newly estimated for the years 1990 to 1994.

f） Source-specific Planned Improvements

No improvements are planned.

4.7.9. Other - Railway Silicon Rectifiers (2.F.9.)

a） Source/Sink 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, 40% was applied. As a result, the uncertainties of the emissions were determined to be 40%. The uncertainty assessment methods are summarized in Annex 7.

- ***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） Source-specific QA/QC and Verification

See section 4.2.1. d）.

e） Source-specific Recalculations

There have been no source-specific recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

4.7.10. Potential Emissions (2.F.P.)

Information on F-gas production, import, and export amounts are collected without differentiating between uses, therefore potential emissions are not reported by category.

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Chapter 5. Solvent and Other Product Use (CRF sector 3)

5.1. Overview of Sector

CO_2, N_2O, and NMVOC are emitted from solvent and other product use. In this chapter, CO_2 and N_2O emissions due to the following product uses are discussed (see Annex 3 for NMVOC):

- Paint application
- Degreasing and dry-cleaning
- Chemical products, manufacture and processing
- Other (e.g. anesthesia)

In 2012, total GHG emissions from the solvent and other product use sector amounted to 91 Gg-CO_2 eq., accounting for 0.01% of total national emissions (excluding LULUCF) from Japan. "3.D.1. Use of Nitrous Oxide for Anesthesia" is the only greenhouse gas emission source in this sector.

5.2. Paint Application (3.A.)

Paint solvents are used in Japan, but their application is basically restricted to mixing, therefore are assumed not to entail chemical reactions. Therefore, they do not generate CO_2 or N_2O during use. They have been reported as "NA."

5.3. Degreasing and Dry-Cleaning (3.B.)

1） CO_2

Degreasing and dry-cleaning are practiced in Japan.

Degreasing is defined as, "washing processes that do not involve chemical reactions", and it is assumed that it does not generate CO_2. Although the CO_2 emissions may occur in association with washing methods involving dry ice or carbonic gas, such methods are not thought to be used in Japan.

There are no processes in dry-cleaning in which chemical reactions may occur, and it is basically assumed that it does not generate CO_2. However washing methods using liquefied carbonic gas are being used experimentally in research facilities and it is not possible to completely negate the possibility of CO_2 emissions.

As a result, these activities have been reported as "NE" due to the fact that there are no sufficient data available on the actual condition of emissions from degreasing and dry-cleaning and the absence of a default emission factor prevents any calculations from being performed.

2） N_2O

Degreasing and dry-cleaning are practiced in Japan, but degreasing is defined as, 'washing processes that do not involve chemical reactions', and there are no processes in dry-cleaning in which chemical reactions may occur. Therefore, it is assumed that N_2O is not generated. In Japan, there are also no methods which have the potential to emit N_2O used for degreasing or dry-cleaning, and they have therefore been reported as "NA".

5.4. Chemical Products, Manufacture and Processing (3.C.)

NMVOC emissions occur from production and use of chemical products. NMVOC is reported in Annex 3.

5.5. Other (3.D.)

5.5.1. Use of Nitrous Oxide for Anesthesia (3.D.1.)

a） Source/Sink 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, therefore CO_2 emissions have been reported as “NA”.

In 2012, total GHG emissions from this category amounted to 91 Gg-CO_2 eq., accounting for 0.01% of total national emissions (excluding LULUCF) from Japan.

Table 5-1 N_2O emissions during anesthetics (laughing gas) use

Gas	Category			Units	1990	1995	2000	2005	2008	2009	2010	2011	2012
N_2O	3.D Other	3.D.1	Use of N_2O for anesthesia	Gg-N_2O	0.93	1.41	1.10	0.86	0.42	0.39	0.32	0.31	0.29
				Gg-CO_2 eq.	287.07	437.58	340.99	266.41	129.10	120.50	98.95	97.15	90.68

b） 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 5-2 Laughing gas shipment amount and N_2O collected in domestic hospitals (calendar year basis)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Laughing gas shipment amount	kg-N_2O	926,030	1,411,534	1,099,979	859,389	417,919	389,749	320,110	314,155	292,971
N_2O collected in domestic hospitals	kg-N_2O	-	-	-	-	1,454	1,049	914	779	450

c） 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.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)*. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.

e） Source-specific Recalculations

More accurate information became available on the laughing gas shipment amount for 2010, resulting in recalculations.

f） Source-specific Planned Improvements

No improvements are planned.

5.5.2. N_2O from Fire Extinguishers (3.D.2)

1） CO_2

Many types of fire extinguishers in Japan are filled with CO_2, which is emitted into the atmosphere when a fire extinguisher is used. All of the CO_2 with which the fire extinguishers are filled, however, is the by-product gas generated from petrochemicals or petroleum refining. Such emissions are included in the calculation of Chapter 1, section 1.A.1.b. Petroleum Refining, and therefore, have been reported as “IE”.

2） N_2O

N_2O is not used in the fire extinguishers in Japan. Therefore the N_2O emissions from this category are reported as “NO”.

5.5.3. N_2O from Aerosol Cans (3.D.-)

1） CO_2

Aerosol products, which fill spray cans with CO_2, are manufactured in Japan. It is assumed that CO_2 could be emitted into the atmosphere when the aerosol products are used. However, because the CO_2 used in the aerosol industry is a by-product gas of petrochemical products, these emissions are counted in the Combustion of Fuel sector (1.A.), and have been reported as “IE” here.

2） N_2O

Aerosol products manufactured in Japan do not use N_2O.Theoretically, no N_2O is emitted, and it has been reported as “NA” here.

References

1. Ministry of the Environment Committee for the Greenhouse Gases Emissions Estimation Methods, *Review of Greenhouse Gases Emissions Estimation Methods Part 2*, August 2002.
2. Ministry of Health, Labour and Welfare, *Statistics of Production by Pharmaceutical Industry*.

Chapter 6. Agriculture (CRF sector 4)

6.1. Overview of Sector

Greenhouse gas emissions from the agricultural sector are calculated in five categories: 4A, 4B, 4C, 4D, and 4F. In 4A: 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 4B: Manure Management, CH_4 and N_2O generated by treatment of manure excreted by cattle, buffalo, sheep, goats, horses, swine and poultry are reported. In 4C: Rice Cultivation, CH_4 emissions from paddy fields (continuously flooded and intermittently flooded) cultivated for rice production are reported. In 4D: Agricultural Soils, CH_4 and N_2O emitted directly and indirectly from agricultural soil as well as pastures, ranges, and paddocks manure are reported. Emissions for 4E 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, which is described in Annex 3) emissions from field burning of grains, legumes, root crops, and sugar cane during agricultural activities are reported in 4F: Field Burning of Agricultural Residues.

The Revised 1996 IPCC Guidelines require emissions from the agricultural sector to be reported as a three-year average. The Japanese inventory uses the year before and the year after the relevant year to report a three-year average for emissions.

GHG emissions in the agricultural sector in FY2012 were 23,905 Gg-CO_2 eq., comprising 1.8% of total emissions (excluding LULUCF). The value represents a reduction by 18.0% from FY1990.

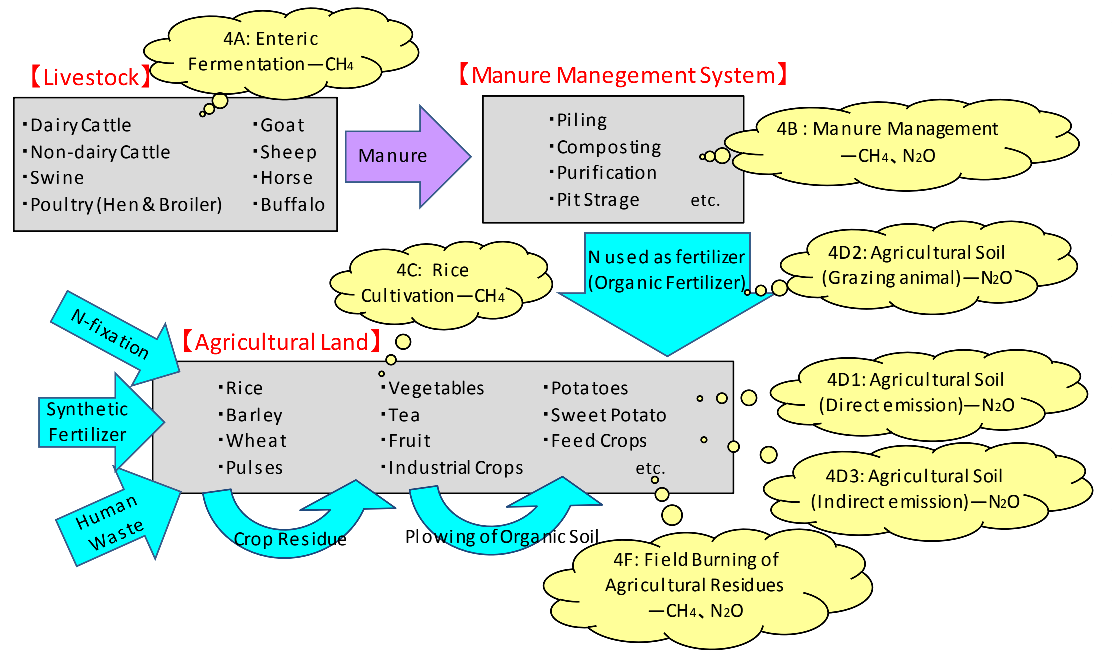

Figure 6-1 Relationships among the categories in the agricultural sector

6.2. Enteric Fermentation (4.A.)

Ruminants such as cattle, buffalo, sheep, and goats have multi-chamber stomachs. The rumen carries

out anaerobic fermentation to break down 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 (4.A.)* section.

GHG emissions from enteric fermentation in FY2012 were 6,379 Gg-CO_2 eq., comprising 0.5% of total emissions (excluding LULUCF). The value represents a reduction by 15.5% from FY1990.

Table 6-1 CH_4 emissions from enteric fermentation

Gas	Livestock species	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CH_4	4.A.1.- Dairy cattle	Gg-CH_4	186.6	178.8	167.8	158.6	150.7	147.8	146.0	144.1	143.2
	4.A.1.- Non-dairy cattle	Gg-CH_4	158.2	164.6	165.5	158.2	162.1	158.5	154.8	150.4	148.3
	4.A.2. Buffalo	Gg-CH_4	0.012	0.007	0.005	0.004	0.004	0.004	0.004	0.005	0.005
	4.A.3. Sheep	Gg-CH_4	0.09	0.06	0.05	0.04	0.05	0.06	0.06	0.06	0.06
	4.A.4. Goats	Gg-CH_4	0.11	0.08	0.09	0.07	0.06	0.06	0.06	0.06	0.06
	4.A.6. Horses	Gg-CH_4	2.1	2.1	1.9	1.6	1.5	1.5	1.5	1.5	1.5
	4.A.8. Swine	Gg-CH_4	12.5	11.0	10.7	10.6	10.8	10.8	10.7	10.7	10.6
	Total	Gg-CH_4	359.5	356.6	346.0	329.1	325.2	318.6	313.2	306.7	303.7
		Gg-CO_2eq	7,550	7,489	7,265	6,912	6,829	6,691	6,577	6,441	6,379

6.2.1. Cattle (4.A.1.)

a) Source/Sink 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 *GPG (2000)* (Page 4.24 Fig. 4.2), calculations for dairy and non-dairy cattle should be performed using the Tier 2 method. The Tier 2 method requires the total energy intake of livestock to be multiplied by the CH_4 conversion factor to derive the emission factor, but it has been in practice in Japan on livestock-related research to use amount of dry matter intake. It is considered that, by applying the results of previous researches, the estimation method using amount of dry matter intake provides more accurate data. 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.

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 the estimation of CH_4 emissions is conducted by type and age.

Table 6-2 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.
Dairy cattle	Non-lactating			—	Cattle of non-lactating period at present.
Dairy cattle	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*.
Dairy cattle	Heifers		5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/24 of the population under 2 years old.	
Dairy cattle	Heifers		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*.
Non-dairy cattle	Breeding cows		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.	
Non-dairy cattle	Breeding cows		5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/12 of the population under 1 year old.	
Non-dairy cattle	Breeding cows		Under 5 months old	Covering 4/12 of the population under 1 year old. Excluded from CH_4 emission estimation.	
Non-dairy cattle	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*.
Non-dairy cattle	fattening cattle	Japanese cattle	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.	
Non-dairy cattle	fattening cattle	Japanese cattle	5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/12 of the population under 1 year old.	
Non-dairy cattle	fattening cattle	Japanese cattle	Under 5 months old	Covering 4/12 of the population under 1 year old. Excluded from CH_4 emission estimation.	
Non-dairy cattle	fattening cattle	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*.
Non-dairy cattle	fattening cattle	Dairy breeds	5 and 6 months old	Calculation covers 5- and 6-month old comprising 2/24 of the population under 2 years old.	
Non-dairy cattle	fattening cattle	Dairy breeds	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 generated from 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 30).

CH_4 emission factor associated with enteric fermentation in cattle [kg-CH_4/head]

$$=(\text{Volume of } CH_4 \text{ generated [l/day/head]}) / (\text{Volume of 1 mol}) \times (\text{molecular weight of } CH_4) \times (\text{No. of days in year})$$

$$= Y / 22.4\ [\text{l/mol}] \times 0.016\ [\text{kg/mol}] \times 365 \text{ or } 366\ [\text{day}]$$

Volume of CH_4 generated per head per day (=Y) [l/day/head]

$$= -17.766 + 42.793\ DMI - 0.849\ (DMI)^2$$

DMI：Dry matter intake [kg/day/head]

Average dry matter intake estimated from Japan Feed Standards compiled by the Japan Livestock Industry Association is 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 at the back of 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 6-3 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*

Table 6-4 Fat content in milk (FAT) and milk yield (MILK) by cattle

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Milk yield (Lactating)	kg/head/day	20.8	22.4	23.5	25.1	25.5	25.7	25.6	25.5	25.8	25.8
Fat content in milk (Lactating)	%	3.7	3.8	3.9	4.0	4.0	3.9	3.9	3.9	3.9	3.9

Table 6-5 Weight by cattle (W)

Animal Type			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Dairy cattle		Lactating	kg/head	595.9	602.8	621.4	622.7	623.0	623.0	623.0	623.0	623.0	623.0
		Non-lactating	kg/head	595.9	602.8	621.4	622.7	623.0	623.0	623.0	623.0	623.0	623.0
		Heifer: under 2 yr, over 6 mth	kg/head	342.4	349.3	364.9	374.2	376.1	376.1	376.1	376.1	376.1	376.1
		Heifer: 5 and 6 mth	kg/head	140.0	140.6	146.3	162.8	166.1	166.1	166.1	166.1	166.1	166.1
Non-dairy cattle	Breeding cows	1 yr and over	kg/head	426.6	426.6	487.3	450.9	429.1	429.1	429.1	429.1	429.1	429.1
		Under 1 yr, over 6 mth	kg/head	230.2	230.2	279.7	259.3	247.0	247.0	247.0	247.0	247.0	247.0
		5 and 6 mth	kg/head	141.0	141.0	157.1	146.8	140.7	140.7	140.7	140.7	140.7	140.7
	Fattening cattle	Japanese cattle (M): 1 yr and over	kg/head	574.3	574.3	574.3	572.3	571.0	571.0	571.0	571.0	571.0	571.0
		Japanese cattle (M): under 1 yr, over 6 mth	kg/head	273.4	273.4	273.4	274.6	275.4	275.4	275.4	275.4	275.4	275.4
		Japanese cattle (M): 5 and 6 mth	kg/head	146.7	146.7	146.7	147.9	148.6	148.6	148.6	148.6	148.6	148.6
		Japanese cattle (F): 1 yr and over	kg/head	388.0	388.0	462.5	427.7	406.8	406.8	406.8	406.8	406.8	406.8
		Japanese cattle (F): under 1 yr, over 6 mth	kg/head	230.2	230.2	279.7	259.3	247.0	247.0	247.0	247.0	247.0	247.0
		Japanese cattle (F): 5 and 6 mth	kg/head	141.0	141.0	157.1	146.8	140.7	140.7	140.7	140.7	140.7	140.7
		Dairy breed: over 6 mth	kg/head	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	kg/head	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8	194.8

Table 6-6 Daily growth by cattle (DG)

Animal Type			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Dairy cattle		Lactating	kg/head/day	—	—	—	—	—	—	—	—	—	—
		Non-lactating	kg/head/day	—	—	—	—	—	—	—	—	—	—
		Heifer: under 2 yr, over 6 mth	kg/head/day	0.60	0.63	0.65	0.59	0.58	0.58	0.58	0.58	0.58	0.58
		Heifer: 5 and 6 mth	kg/head/day	0.69	0.70	0.76	0.88	0.90	0.90	0.90	0.90	0.90	0.90
Non-dairy cattle	Breeding cows	1 yr and over	kg/head/day	0.17	0.17	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13
		Under 1 yr, over 6 mth	kg/head/day	0.70	0.70	0.94	0.86	0.81	0.81	0.81	0.81	0.81	0.81
		5 and 6 mth	kg/head/day	0.74	0.74	1.04	0.96	0.91	0.91	0.91	0.91	0.91	0.91
	Fattening cattle	Japanese cattle (M): 1 yr and over	kg/head/day	0.60	0.60	0.60	0.59	0.58	0.58	0.58	0.58	0.58	0.58
		Japanese cattle (M): under 1 yr, over 6 mth	kg/head/day	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	kg/head/day	0.94	0.94	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95
		Japanese cattle (F): 1 yr and over	kg/head/day	0.28	0.28	0.27	0.25	0.24	0.24	0.24	0.24	0.24	0.24
		Japanese cattle (F): under 1 yr, over 6 mth	kg/head/day	0.70	0.70	0.94	0.86	0.81	0.81	0.81	0.81	0.81	0.81
		Japanese cattle (F): 5 and 6 mth	kg/head/day	0.74	0.74	1.04	0.96	0.91	0.91	0.91	0.91	0.91	0.91
		Dairy breed: over 6 mth	kg/head/day	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	kg/head/day	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10

Table 6-7 Dry matter intake by cattle (DMI)

Animal Type			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Dairy cattle		Lactating	kg/head/day	16.6	17.4	18.1	18.9	18.9	19.0	18.9	18.9	19.0	19.0
		Non-lactating	kg/head/day	8.2	8.3	8.5	8.5	10.6	10.6	10.6	10.6	10.6	10.6
		Heifer: under 2 yr, over 6 mth	kg/head/day	7.1	7.2	7.5	7.7	7.7	7.7	7.7	7.7	7.7	7.7
		Heifer: 5 and 6 mth	kg/head/day	3.6	3.6	3.8	4.2	4.3	4.3	4.3	4.3	4.3	4.3
Non-dairy cattle	Breeding cows	1 yr and over	kg/head/day	6.6	6.6	7.1	6.6	6.3	6.3	6.3	6.3	6.3	6.3
		Under 1 yr, over 6 mth	kg/head/day	5.5	5.5	6.7	6.2	5.9	5.9	5.9	5.9	5.9	5.9
		5 and 6 mth	kg/head/day	3.8	3.8	4.4	4.1	4.0	4.0	4.0	4.0	4.0	4.0
	Fattening cattle	Japanese cattle (M): 1 yr and over	kg/head/day	8.4	8.4	8.4	8.3	7.7	7.7	7.7	7.7	7.7	7.7
		Japanese cattle (M): under 1 yr, over 6 mth	kg/head/day	6.8	6.8	6.8	6.8	7.2	7.2	7.2	7.2	7.2	7.2
		Japanese cattle (M): 5 and 6 mth	kg/head/day	4.3	4.3	4.3	4.4	4.4	4.4	4.4	4.4	4.4	4.4
		Japanese cattle (F): 1 yr and over	kg/head/day	5.7	5.7	6.4	6.0	5.7	5.7	5.7	5.7	5.7	5.7
		Japanese cattle (F): under 1 yr, over 6 mth	kg/head/day	4.9	4.9	6.1	5.6	5.3	5.3	5.3	5.3	5.3	5.3
		Japanese cattle (F): 5 and 6 mth	kg/head/day	3.4	3.4	4.1	3.8	3.6	3.6	3.6	3.6	3.6	3.6
		Dairy breed: over 6 mth	kg/head/day	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	kg/head/day	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3

Table 6-8 Emission factor associated with enteric fermentation by cattle

Animal Type			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Dairy cattle		Lactating	kg-CH_4/head/yr	119.5	122.8	124.9	127.1	127.3	127.4	127.1	127.5	127.4	127.4
		Non-lactating	kg-CH_4/head/yr	72.0	72.7	74.0	74.1	88.7	88.7	88.7	88.9	88.7	88.7
		Heifer: under 2 yr, over 6 mth	kg-CH_4/head/yr	63.4	64.7	66.9	67.8	68.0	68.0	68.0	68.1	68.0	68.0
		Heifer: 5 and 6 mth	kg-CH_4/head/yr	32.7	32.9	34.4	38.1	38.8	38.8	38.8	38.9	38.8	38.8
Non-dairy cattle	Breeding cows	1 yr and over	kg-CH_4/head/yr	59.0	59.2	63.1	59.3	57.0	57.0	57.0	57.1	57.0	57.0
		Under 1 yr, over 6 mth	kg-CH_4/head/yr	49.8	50.0	60.1	56.3	53.8	53.8	53.8	54.0	53.8	53.8
		5 and 6 mth	kg-CH_4/head/yr	34.9	35.0	40.4	37.8	36.2	36.2	36.2	36.3	36.2	36.2
	Fattening cattle	Japanese cattle (M): 1 yr and over	kg-CH_4/head/yr	73.2	73.4	73.2	72.8	68.5	68.5	68.5	68.7	68.5	68.5
		Japanese cattle (M): under 1 yr, over 6 mth	kg-CH_4/head/yr	61.1	61.3	61.1	61.2	64.5	64.5	64.5	64.7	64.5	64.5
		Japanese cattle (M): 5 and 6 mth	kg-CH_4/head/yr	39.6	39.7	39.6	39.9	39.8	39.8	39.8	39.9	39.8	39.8
		Japanese cattle (F): 1 yr and over	kg-CH_4/head/yr	51.8	51.9	58.1	54.2	51.9	51.9	51.9	52.0	51.9	51.9
		Japanese cattle (F): under 1 yr, over 6 mth	kg-CH_4/head/yr	44.3	44.5	55.3	51.2	48.7	48.7	48.7	48.8	48.7	48.7
		Japanese cattle (F): 5 and 6 mth	kg-CH_4/head/yr	31.0	31.0	37.4	34.6	32.9	32.9	32.9	33.0	32.9	32.9
		Dairy breed: over 6 mth	kg-CH_4/head/yr	75.6	75.8	75.6	75.6	75.6	75.6	75.6	75.8	75.6	75.6
		Dairy breed: 5 and 6 mth	kg-CH_4/head/yr	48.0	48.1	48.0	48.0	48.0	48.0	48.0	48.1	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 6-9 Livestock population for cattle (single year)

Animal Type			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Dairy cattle		Lactating	1000 head	1,082	1,035	971	900	848	830	805	813	798	798
		Non-lactating	1000 head	332	299	249	231	207	200	195	200	194	194
		Heifer: under 2 yr, over 6 mth	1000 head	491	445	379	379	334	341	351	328	323	323
		Heifer: 5 and 6 mth	1000 head	55	49	42	42	37	38	39	36	36	36
		Heifer: under 5 mth	1000 head	109	99	84	84	74	76	78	73	72	72
Dairy cattle total			1000 head	**2,068**	**1,927**	**1,725**	**1,636**	**1,500**	**1,484**	**1,467**	**1,449**	**1,423**	**1,423**
Non-dairy cattle	Breeding cows	1 yr and over	1000 head	679	646	612	594	650	651	636	614	593	593
		Under 1 yr, over 6 mth	1000 head	17	13	12	14	16	17	16	14	13	13
		5 and 6 mth	1000 head	6	4	4	5	5	6	5	5	4	4
		Under 5 mth	1000 head	12	9	8	9	10	11	11	9	9	9
	Fattening cattle	Japanese cattle (M): 1 yr and over	1000 head	368	412	385	374	414	425	409	405	396	396
		Japanese cattle (M): under 1 yr, over 6 mth	1000 head	125	133	114	119	130	132	127	123	116	116
		Japanese cattle (M): 5 and 6 mth	1000 head	42	44	38	40	43	44	42	41	39	39
		Japanese cattle (M): under 5 mth	1000 head	83	89	76	80	87	88	85	82	77	77
		Japanese cattle (F): 1 yr and over	1000 head	197	265	246	290	323	339	336	343	337	337
		Japanese cattle (F): under 1 yr, over 6 mth	1000 head	102	105	93	89	105	106	101	98	93	93
		Japanese cattle (F): 5 and 6 mth	1000 head	34	35	31	30	35	35	34	33	31	31
		Japanese cattle (F): under 5 mth	1000 head	68	70	62	59	70	70	67	65	62	62
		Dairy breed: over 6 mth	1000 head	805	808	845	789	775	726	671	669	655	655
		Dairy breed: 5 and 6 mth	1000 head	89	90	94	88	86	81	75	74	73	73
		Dairy breed: under 5 mth	1000 head	179	180	188	175	172	161	149	149	146	146
Non-dairy cattle total			1000 head	**2,805**	**2,901**	**2,805**	**2,755**	**2,922**	**2,892**	**2,763**	**2,723**	**2,642**	**2,642**

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

An uncertainty assessment was conducted for the categories indicated in Table 6-2, there were 4 categories for dairy cattle and 11 categories for non-dairy cattle. The uncertainties for emission factors were calculated by finding the 95% confidence interval in accordance with the equation indicated in the section Emission Factors. 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 determined to be 5% in accordance with decision tree indicated in Annex 7. As a result, the uncertainties of the emissions were determined to be 15% for dairy cattle and 19% for non-dairy cattle. The uncertainty assessment methods are summarized in Annex 7.

- ***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 FY1989 onward from the data in the *Livestock Statistics*.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

Comparison between results of Japan's estimation method and IPCC Tier 2 method was conducted. For Tier2 method, equations indicated in the GPG (2000) (Equation 4.1~4.11) are used, and estimation is conducted by classification described in Table 6-2 above. If data is available, Japan's data are used (e.g. values of Table 6-3 ~ 6-7 above and values of DE calculated from data described in the *Japan Feed Standards* (Reference 25). If not available, default data described in GPG (2000) are used (e.g. Ym, Cfi and Cpregnancy).

As a result, for dairy cattle, considering the error of CH_4 conversion factor (Ym = 0.60 $\pm$ 0.05), 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. On the other hand, for non-dairy cattle, it became clear that the emissions of Japan's method are higher than IPCC Tier 2 method (in the case of Ym=0.60, 12% to 17% higher). Analysis of the factor about this difference will be continued.

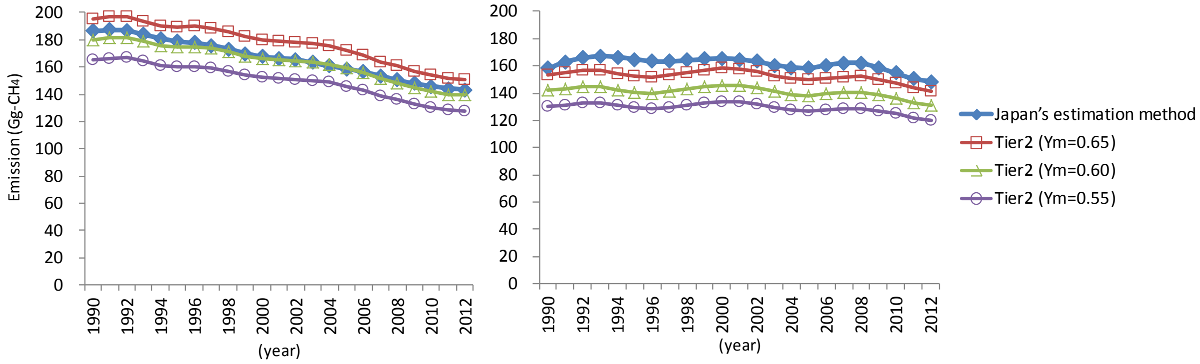

Figure 6-2 Comparison between results of Japan's estimation method and IPCC Tier 2 method (Left: Dairy cattle, Right: Non-dairy cattle)

e） Source-specific Recalculations

For dairy cattle, milk yield for all years were revised. Therefore, emissions from dairy cattle were revised. In addition, since the fat content in milk (FAT) was updated, the emissions from dairy cattle for FY2011 were revised. In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f） Source-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.

6.2.2. Buffalo, Sheep, Goats, Horses & Swine (4.A.2., 4.A.3., 4.A.4., 4.A.6., 4.A.8.)

a） Source/Sink 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 *GPG (2000)*.

- ***Emission Factors***

The emission factor for CH_4 associated with sheep and goats has been established by the value of dry matter intake and the equation of CH_4 emission estimated from dry matter intake given by Shibata (1993) (see p.6-3 the equation "CH_4 emission factor associated with enteric fermentation in cattle").

In Japan, most of sheep are farmed for meat and they are smaller than sheep for wool production assumed in the *Revised 1996 IPCC Guidelines* and *GPG (2000)* as default. Therefore, it is considered that emission factor for sheep in Japan is lower than default in IPCC guidelines. As for goats, research findings in this regard do not exist in Japan. However, the emission factor for goat was regarded as equivalent to the one for sheep by the experts (the expert judgment). Therefore, the emission factor for sheep is also used for goats.

The emission factor for swine has been established on the basis of results of research conducted in Japan. This emission factor is lower than default emission factor. The reason for this is considered that Japan's swine is smaller than overseas swine (Weight at shipment for fattening swine is about 110 kg in Japan).

The emission factor used for horses and buffalo is the default value given in the *Revised 1996 IPCC Guidelines*.

Table 6-10 Emission factors for CH_4 associated with enteric fermentation in sheep, goats, horses, swine and buffalo

Animal type	Dry matter intake [kg]	CH_4 emission factor [kg/year/head]
Sheep and goats	0.8[a]	4.1[a,b]
Swine	–	1.1[c]
Horses	–	18.0[d]
Buffalo	–	55.0[d]

a: Shibata et al., "Estimation of Methane Production in Ruminants", Animal Sciences and Technology, 1993 (Reference 30)
b: Calculated by the formula of CH_4 emissions estimated from dry matter intake (see p.6-3 the equation "CH_4 emission factor associated with enteric fermentation in cattle")
c: Mamoru Saito, *Methane emissions from fattening swine and expectant swine* (1988) (Reference 29)
d: *Revised 1996 IPCC Guidelines* (Reference 3)

● ***Activity Data***

The values used for activity data are used for sheep and goats given in the *Statistical Document of Livestock Breeding* offered by the Japan Livestock Industry Association. The values used for activity data for swine are the herd size at February 1st in each year, as recorded by the MAFF in its *Livestock Statistics*. The values used for activity data for horses given in the *Statistical Document of Horse* offered by the MAFF, for buffalo given *Statistics on Livestock in Okinawa Prefecture*.

Table 6-11 Activity data associated with enteric fermentation by buffalo, sheep, goats, swine, and horses

Type of animal	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Sheep	1000 head	21	14	12	9	12	14	14	14	14	14
Goats	1000 head	26	19	22	16	14	14	14	14	14	14
Swine	1000 head	11,336	9,900	9,788	9,621	9,900	9,834	9,768	9,736	9,684	9,684
Horses	1000 head	116	118	105	87	*81*	81	81	81	81	81
Buffalo	1000 head	0.21	0.12	0.10	0.08	0.08	0.08	0.08	0.08	0.09	0.09

c) Uncertainties and Time-series Consistency

● ***Uncertainties***

An uncertainty assessment was conducted by each livestock category. The uncertainties for emission factors were applied 50% of default data given in the *GPG (2000)*. As the uncertainty for activity data, 0.9% of standard error for swine given in the *Livestock Statistic* was applied to swine. Since sample standard deviation can't be obtained and expert judgment is impossible, and non-fundamental statistics, 100% was applied to other livestock in accordance with the decision tree of uncertainty assessment. As a result, the uncertainties of the emissions were determined to be 50% for swine and 112% for buffalo, sheep and goats. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

For emission factors, same values were used consistently from FY1990 to FY2012. Activity data for sheep and goats applied the data given in the *Statistical Document of Livestock Breeding*, those for swine applied the data given in the *Livestock Statistics*; those for horses applied the data given in *Statistical Document of Horse*, and those for buffalo applied the data given in the *Livestock Statistics of Okinawa*, consistently since FY1989.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

With regard to the reason that Japan's EF is lower than the default EF in the IPCC Guidelines for sheep and swine, it is described in the 'emissions factors' section above.

e） Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f） Source-specific Planned Improvements

Although the default emission factor in the *Revised 1996 IPCC Guidelines* or the *GPG (2000)* has been used for some livestock categories, there is a need to discuss whether it is possible to establish country-specific emission factors for Japan.

6.2.3. Poultry (4.A.9.)

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 1996 IPCC Guidelines* nor the *GPG (2000)* offer default emission factors. Therefore, this category has been reported as "NE". In addition, poultry other than hens and broiler are not covered by official statistics, suggesting that they may be assumed to be negligible.

6.2.4. Camels and Llamas, Mules and Asses (4.A.5., 4.A.7.)

Japan reported "NO" in this subcategory as it was unlikely that these animals were raised for agricultural purposes.

6.2.5. Other (4.A.10.)

The only livestock that are bred in Japan are cattle, buffalo, sheep, goats, horses, swine and poultry. Therefore, this category has been reported as "NO".

6.3. Manure Management (4.B.)

Livestock manure generates CH_4 when its organic content is converted to CH_4 gas through CH_4

fermentation, or when CH_4 from 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.

CH_4 and N_2O emissions from manure management in FY2012 are 2,121 Gg-CO_2 eq. and 3,712 Gg-CO_2 eq., comprising 0.2% and 0.3% of total emissions (excluding LULUCF), respectively. The value represents a reduction by 28.1% for CH_4 and an increase by 17.0% for N_2O from FY1990.

Table 6-12 CH_4 and N_2O emissions from livestock manure management

Gas	Livestock species	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CH_4	4.B.1.- Dairy cattle	Gg-CH_4	116.1	108.8	100.0	94.2	89.5	88.1	87.3	86.1	85.5
	4.B.1.- Non-dairy cattle	Gg-CH_4	4.5	4.6	4.6	5.2	5.8	5.8	5.8	5.6	5.5
	4.B.2. Buffalo	Gg-CH_4	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	4.B.3. Sheep	Gg-CH_4	0.006	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004
	4.B.4. Goats	Gg-CH_4	0.005	0.003	0.004	0.003	0.003	0.002	0.002	0.002	0.002
	4.B.6. Horses	Gg-CH_4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	4.B.8. Swine	Gg-CH_4	17.3	15.1	13.9	9.7	7.6	7.1	6.8	6.8	6.8
	4.B.9. Poultry	Gg-CH_4	2.3	2.2	2.1	2.4	2.7	2.8	2.9	3.0	3.0
	Total	Gg-CH_4	140.4	131.0	120.9	111.8	105.8	104.1	102.9	101.6	101.0
		Gg-CO_2eq	2,949	2,752	2,538	2,347	2,223	2,185	2,162	2,134	2,121
N_2O	4.B.1.- Dairy cattle	Gg-N_2O	2.8	2.6	2.5	2.8	3.0	3.0	3.1	3.0	3.0
	4.B.1.- Non-dairy cattle	Gg-N_2O	2.8	2.9	2.9	3.0	3.3	3.3	3.3	3.2	3.1
	4.B.2. Buffalo	Gg-N_2O	0.00004	0.00002	0.00002	0.00001	0.00001	0.00001	0.00001	0.00001	0.00002
	4.B.3. Sheep	Gg-N_2O	0.0003	0.0002	0.0002	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002
	4.B.4. Goats	Gg-N_2O	0.0004	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002
	4.B.6. Horses	Gg-N_2O	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001
	4.B.8. Swine	Gg-N_2O	3.2	2.8	2.9	3.6	4.1	4.1	4.2	4.2	4.1
	4.B.9. Poultry	Gg-N_2O	1.4	1.4	1.3	1.5	1.6	1.7	1.7	1.7	1.7
	Total	Gg-N_2O	10.2	9.7	9.6	11.0	12.0	12.2	12.2	12.0	12.0
		Gg-CO_2eq	3,171	3,021	2,983	3,402	3,734	3,776	3,779	3,734	3,712
Total of all gases		Gg-CO_2eq	6,120	5,773	5,521	5,749	5,956	5,961	5,940	5,868	5,833

6.3.1. Cattle, Swine and Poultry (4.B.1., 4.B.8., 4.B.9.)

a) Source/Sink 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 "4.D.2 Pasture, Range and Paddock Manure".

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.

$$E = \sum \left(EF_n \times A_n \right)$$

E: CH_4 emissions associated with the management of manure excreted by cattle, swine and poultry [g-CH_4]

EF_n: Emission factor for treatment method n [g-CH_4/g-organic matter];

A_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.

$$E = \sum \left(EF_n \times A_n \right) \times 44/28$$

E: N_2O emission associated with management of manure excreted by cattle, swine and poultry [g-N_2O]

EF_n: Emission factor for treatment method n [g-N_2O/g-N];

A_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 6-3.

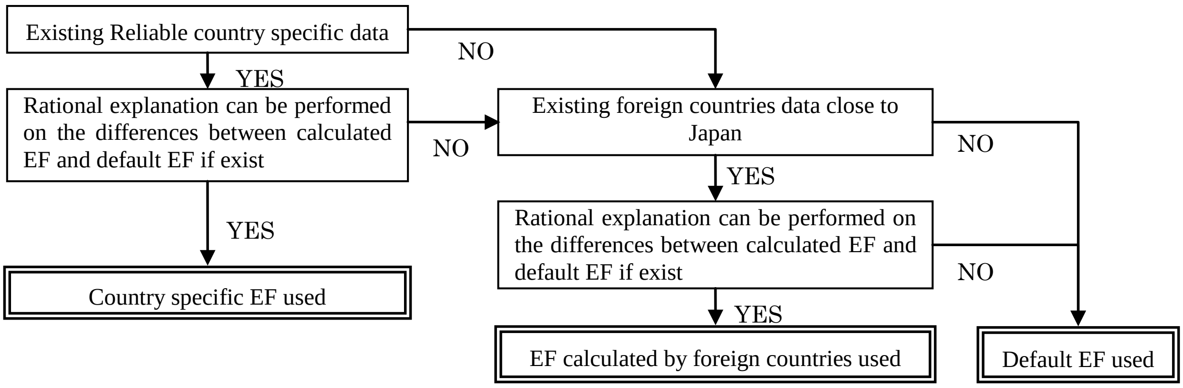

Figure 6-3 Decision tree for determination of EF

Emission factors for CH_4 indicated by "D (default value)" in Table 6-13 were calculated by following equation with Bo (maximum methane producing capacity) (Dairy cattle: 0.13, Non-dairy cattle: 0.10, Swine: 0.29, Poultry: 0.32) and MCF (methane conversion factor) in "Temperate" and "Asia" indicated in the *GPG (2000)* and the *Revised 1996 IPCC Guidelines*.

$$EF_n = Bo\ [m^3\text{-}CH_4/kg\text{-organic matter}] \times 0.67\ [kg\text{-}CH_4/m^3\text{-}CH_4] \times MCF\ [\%]$$

For country-specific emission factors, MCF values are not established because emission factors are estimated directly from results of actual measurement data.

Table 6-13 MCFs (methane conversion factor) used for calculation of default emission factors

Treating method	MCF	System in GPG (2000)
12. Pit storage (non-dairy cattle, swine)	45 %	Liquid/ Slurry
14b./ 14e. Composting (dairy cattle, non-dairy cattle, swine, poultry)	0.5%	Composting - Intensive
14f. Purification (dairy cattle, non-dairy cattle)	0.1%	Aerobic treatment

* For other treating method than the above, MCF values are not established because country-specific emission factors are used.

Reference: GPG (2000), Table4-10, 4-11, Temperate (Reference 4)

For "Piling", the most major manure management practice in Japan, Osada et, al. (2005, Reference 38) 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

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 (Reference58)). 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 6-15). 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 6-14 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	
12. Pit storage		Table 6-16	J[10]	3.00 %	D[1]	8.7 %	D[1]	—	
13. Sun drying		0.20 %	J[3]	0.20 %	J[3]	0.20 %	J[3]	0.14 %	J[12]
14. Other	14a. Thermal drying	0 %							Z[4]
	14b. Composting (feces)	0.044 %	D[1]	0.034 %	D[1]	0.080 %	J[9]	0.080%	Sw
	14c. Piling	3.80 %	J[5]	0.13 %	J[5]	0.16 %	J[5]	Hen: 0.13 %, Broiler 0.02 %	J[14]
	14d. Incineration	0.4 %							O[4,6]
	14e. Composting (urine)	0.044 %	D[1]	0.034 %	D[1]	0.097 %	D[1]	—	
	14e. Composting (feces and urine mixed)					0.080 %	J[9]		
	14f. Purification	0.0087%	D[1]	0.0067%	D[1]	0.91 %	J[13]		
	14g. Methane fermentation (feces)	3.80%	Pl	0.13%	Pl	0.16%	Pl	Hen: 0.13 %, Broiler 0.02 %	Pl
	14g. Methane fermentation (feces and urine mixed)	Table 6-16	J[10]	3.0%	PS	8.7%	PS	—	
	14i. Pasture, range and paddock	0.095%			J[11]	—		0.14%	SD
	14k. Other (feces)	3.80%	M	0.4%	M	0.4%	M	0.4%	M
	14k. Other (feces and urine mixed)	3.90%	M	3.0%	M	8.7%	M	—	

* For notation and sources in this table, see Table 6-15 below.

Table 6-15 N_2O Emission factors for each method of treating manure from cattle, swine hen & broiler ($g\text{-}N_2O\text{-}N/g\text{-}N$)

treating method		Dairy cattle		Non-dairy cattle		Swine		Hen, Broiler	
12. Pit storage		0.02%	J[10]	0.10 %			D[1]		
13. Sun drying		2.0 %					D[1]	0.33%	J[12]
14. Other	14a. Thermal drying	2.0 %							D[1]
	14b. Composting (feces)	0.25 %			J[7]	0.16 %	J[9]	0.16 %	Sw
	14c. Piling	2.40 %	J[5]	1.60 %	J[5]	2.50 %	J[5]	Hen: 0.54%, Broiler 0.08%	J[14]
	14d. Incineration	0.1 %							O[4]
	14e. Composting (urine)	2.0%					D[1]	—	
	14e. Composting (feces and urine mixed)	2.0%	D[1]	0.25%	J[7]	0.16%	J[9]		
	14f. Purification	5.0 %			J[8]	2.87%	J[13]		
	14g. Methane fermentation (feces)	2.40 %	Pl	1.60 %	Pl	2.50 %	Pl	Hen: 0.54%, Broiler 0.08%	Pl
	14g. Methane fermentation (feces and urine mixed)	0.15%	J[10]	0.1 %			PS	—	
	14i. Pasture, range and paddock	0.485%			J[11]	—		0.33%	SD
	14k. Other (feces)	2.4%	M	2.0%	M	2.5%	M	2.0%	M
	14k. Other (feces and urine mixed)	5.0%	M	5.0%	M	2.87%	M	—	

D: Default value of *Revised 1996 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 6-13 and Table 6-14

1: GPG (2000) (Reference 4)
2: IPCC, *Revised 1996 IPCC Guidelines* (Reference 3)
3: Makoto Ishibashi et al., *"Development of technology of reducing GHG on the livestock industry(second report)"* (2003) (Reference 34)
4: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*, (2002) (Reference 22)
5: Takashi Osada et al., *Greenhouse gas generation from livestock waste composting* (2005) (Reference 38)
6: IPCC(1995): IPCC 1995 Report (Reference 2)
7: Takashi Osada et al., *Determination of nitrous oxide, methane, and ammonia emissions from a swine waste composting process* (2000) (Reference 36)
8: Takashi Osada, *Nitrous Oxide Emission from Purification of Liquid Portion of Swine Wastewater* (2003) (Reference 37)
9: *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 47)
10: 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 58)

11: Setting value by experts on the Break Out Group on Agriculture of the Committee for GHG Emissions Estimation Method

12: Izumi Tsuchiya, et al., *Measurement of greenhouse gas emissions in drying treatment facility for poultry manure* (2013) (Reference 60)

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 FY2012* (2013) (Reference 61)

14: 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 62)

Table 6-16 CH_4 Emission factors for "Pit storage" and "Methane fermentation" for dairy cattle

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Pit storage	g-CH_4/g-organic matter	2.47%	2.44%	2.42%	2.40%	2.39%	2.38%	2.37%	2.37%	2.37%	2.37%
Methane fermentation	g-CH_4/g-organic matter	3.22%	3.17%	3.14%	3.11%	3.08%	3.07%	3.06%	3.06%	3.06%	3.06%

Note: These figures are weighted averages of regional emission factors by MAFF survey (Reference 58, No.10) 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.

Total annual amount of organic matter by domestic 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 6-19 and 6-20).

For livestock population, same references indicated in '4.A. Enteric Fermentation' are used.

Estimating activity data for CH_4 (amount of organic matter excreted)

Amount of organic matter excreted [Gg] ＝ Livestock population [1000 head]
× Amount of feces and urine excreted [kg/head/day] × days per year [day]
× organic matter content in feces and urine [%] × proportions of feces and urine separated [%]
× share of each treating method [%] / 1000

Estimating activity data for N_2O (amount of nitrogen excreted by each type of livestock)

Amount of nitrogen excreted [Gg-N] ＝ Livestock population [1000 head]
× Nitrogen content amount of feces and urine excreted [kg-N/head/day] × Days per year [day]
× Proportion of feces and urine separated [%] × Share of each treating method [%] / 1000

Table 6-17 Livestock population for hen and broiler

Type of livestock	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Hen	1000 head	188,786	190,634	186,202	180,697	180,994	179,770	178,546	177,607	174,784	174,784
Broiler	1000 head	142,740	118,123	106,311	103,687	107,141	113,262	119,383	125,503	131,624	131,624

Table 6-18 Amount of feces and urine excreted and nitrogen content amount by type of livestock

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 44)

Table 6-19 Organic matter content in feces and urine, by type of livestock (wet base)

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 22)

Table 6-20 Percentage of manure management by type of animal (dairy cattle, non-dairy cattle and swine)

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 23)
2009~: MAFF, *Survey of current status for livestock manure management system* (2009) (Reference 57)
*: For dairy cattle and non-dairy cattle, percentage of "Pasturage" are not indicated in Japan Livestock Association data (Reference 23). Therefore, the percentages of "Pasturage" indicated in Reference 57 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 6-21 Percentage of manure management by type of animal (hen and broiler)

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 6-20 above

Table 6-22 Proportion of separated and mixed treatment of manure, by type of livestock

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 22),
From 2009 onward: MAFF, *Survey of current status for livestock manure management system* (2009) (Reference 57)

- ***Completeness***

Poultry other than hens and broiler are not covered by official statistics, and they are assumed to be negligible. Therefore, only hens and broiler are considered as estimation target from poultry.

- ***Climate Regions***

In the Tier 1 method, the *GPG (2000)* requires that emissions be calculated using herd size by climate regions.

In accordance with the climate categories given in the *Revised 1996 IPCC Guidelines*, Japan should be divided into temperate and cool zones. The average temperature over all prefectures in Japan is around 15 ºC. This figure is almost the same as the threshold given in the *Revised 1996 IPCC Guidelines*. Therefore, emissions have been calculated on the assumption that all of Japan falls into the temperate zone, without a need to categorize regions into temperate or cool zone.

- ***Reporting in Common Reporting Format (CRF)***

In the CRF, with regard to CH_4 emissions from this category, it is required to report emissions by each livestock. However, for N_2O emissions from this category, it is required to report emissions by AWMS (11. Anaerobic Lagoons, 12. Liquid Systems, 13. Solid Storage and Dry Lot, 14. 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 6-21 below.

The current CRF divides the reporting categories into anaerobic lagoons, liquid systems, solid storage and dry lots, and other. In Japan, however, composting is widely practiced, particularly with respect to domestic livestock feces. Consequently the composting-related subcategories of "Piling" and "Composting" have been established under the "Other" category. Additional subcategories of "Thermal drying" and "Incineration", which are practiced for the purposes of amount reduction and easier handling of dung, have been also included in the other category. Urine undergoes purification treatment as sewage with high concentrations of pollutants. Accordingly, a subcategory of "Purification" has been added to the CRF category of "Other".

Composting 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.

"11. 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.

Table 6-23 Correspondence between the Japanese and CRF manure management categories

Sub-categories in Japan			CRF	Description of treatment
Manure treatment		Manure management category		
Separate treatment	Feces	Sun drying	13. Solid storage and dry lot	Dried under sunlight to facilitate handling (for storage and odor prevention).
		Thermal drying	14. Other (a. Thermal drying)	Dried by heat to facilitate handling.
		Composting	14. Other (b. Composting)	Fermented for several days to several weeks with forced aeration and agitation in lidded or closed tanks.
		Piling	14. Other (c. Piling)	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	14. Other (d. Incineration)	For amount reduction or disposal, and use as an energy source (e.g. chicken manure boiler).
		Methane fermentation	14. Other (g. Methane fermentation (feces))	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	14. Other (i. Pasture, range and paddock)	Livestock are fed on a land with vegetation to eat. N_2O Emissions are reported in the 'Pasture, Range and Paddock (4.D.2.)'
		Other	14. Other (k. Other (feces))	Treated with the method not mentioned above.
	Urine	Liquid composting	14. Other (e. Composting (liquid))	Treated in an aeration storage tank.
		Purification	14. Other (f. Purification)	Separate pollutants using aerobic microbes, such as activated sludge.
		Pit storage	12. Liquid systems	Stored in a storage tank.
		Methane fermentation	14. Other (g. Methane fermentation (mixed))	Same as above (Methane fermentation)
		Public sewage	-	Same as above (Public sewage)
		Other	14. Other (k. Other (mixed))	Treated with the method not mentioned above.
Mixed treatment		Sun drying	13. Solid storage and dry lot	Dried under sunlight to facilitate handling.
		Thermal drying	14. Other (a. Thermal drying)	Same as above, Thermal drying.
		Liquid composting	14. Other (e. Composting (liquid))	Treated in an aeration storage tank.
		Piling	14. Other (c. Piling)	Same as above, Piling.
		Purification	14. Other (f. Purification)	Same as above, Purification.
		Pit storage	12. Liquid systems	Stored in a storage tank (e.g. slurry storage).
		Methane fermentation	14. Other (g. Methane fermentation (mixed))	Same as above (Methane fermentation).
		Public sewage	-	Same as above (Public sewage)
		Pasture, range and paddock	14. Other (i. Pasture, range and paddock)	Same as above (Pasture, range and paddock)
		Other	14. Other (k. Other (mixed))	Treated with method not mentioned above

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

For the uncertainties of the emission factors for livestock, the values by each livestock category given in the *GPG (2000)* and the values calculated by expert judgment in accordance with the decision tree for uncertainty assessment, were applied.

For the uncertainties of the activity data, 0.9% (the standard error for swine given in the *Livestock Statistics*) was applied to swine, and 12.4% (the standard error for hens given in the *Livestock Statistics*) was applied to hens, and broilers. For cattle, 5% is adopted, same as "6.2.1. Enteric

Fermentation, Cattle”.

As a result, the uncertainties of the emissions for CH_4 and N_2O were determined to be 78% and 91% for dairy cattle, 73% and 125% for non-dairy cattle, 106% and 92% for swine, 54% and 80% for poultry, respectively. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emission factors were used consistently from FY1989 onward by the method. Activity data were calculated consistently from FY1989 onward from the data in the *Livestock Statistics*.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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 Annex 6.1.

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 GPG (2000). 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 GPG (2000). 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, reason is guessed 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. This reason is guessed 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. This reason is guessed 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） Source-specific Recalculations

For sun drying and piling for poultry, and purification for swine, new emission factors were developed. Therefore, emissions for all years were revised. In addition, years applying survey data for “percentage of manure management by type of animal” and “ proportion of separated and mixed treatment of manure, by type of livestock” were revised. (Interpolation were applied from FY2000 to FY2008.) Therefore, emissions from FY1999 to FY2009 were revised. In the agriculture sector, a

3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f）Source-specific Planned Improvements

As research on actual emissions 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.

In addition, since the estimation of the amount of nitrogen fertilized in agricultural soil from livestock manure has a possibility of overestimate, the nitrogen flow in the whole agriculture sector has been continuously investigated in the Committee for Greenhouse Gas Emission Estimation Methods.

6.3.2. Buffalo, Sheep, Goats & Horses (4.B.2., 4.B.3., 4.B.4., 4.B.6.)

a）Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions for manure management from buffalo, sheep, goats and horses.

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 *GPG (2000)* (Page 4.33, Fig. 4.3 and Fig. 4.4).

CH_4 emissions associated with manure management [kg-CH_4]   = Emission factor for animal [kg-CH_4/year/head] × Population of the animal [head]

N_2O emission associated with livestock manure [kg-N_2O]   = Emission factor per manure management category of each type of animal [kg-N_2O-N/kg-N])   × Nitrogen content of manure [kg-N/head] × Percentage of manure management category   × Population of livestock [head]

- ***Emission Factors***

For the emission factors for CH_4, the default values for temperate zones in industrialized nations, given in the *Revised 1996 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 of “Other animals” for temperate zones in “Asia & Far East”, given in the *Revised 1996 IPCC Guidelines* were used.

Table 6-24 Emission factors for sheep, goats and horses

Type of livestock	Emission factors [kg-CH_4/head/year]	Reference
Sheep	0.28	*Revised 1996 IPCC Guidelines* Vol. 2 p. 4.6 Table 4-4
Goats	0.18	
Horses	2.08	
Buffalo	2	*Revised 1996 IPCC Guidelines*, Vol. 3, p. 4.13, Table 4-6

Table 6-25 Emission factors for buffalo, sheep, goats and horses

Manure management category		[kg-N_2O-N/ kg-N]
11. Anaerobic lagoons		0.1%
12. Liquid systems (pit storage)		0.1%
13. Solid storage and dry lot (sun drying)		2.0%
14. Other	h. Daily spread	0.0%
	i. Pasture range and paddock	2.0%
	j. Used fuel	0.0%
	k. Other system	0.5%

Source: *Revised 1966 IPCC Guidelines*, Vol. 3, page 4.121, Table B-1 (Reference 3)

- ***Activity Data***

For CH_4, same as '4.A. Enteric Fermentation', Calculation of activity data for sheep and goats used the values listed in the *Statistical Document of Livestock Breeding* offered by the Japan Livestock Industry Association and horses used the values listed in the *Statistical Document of Horse* offered by the MAFF. Data for buffalo in the calculation used the population of buffalo listed in the *Statistics on Livestock in Okinawa Prefecture* (Table 6-11).

For N_2O, in order to determine the activity data for buffalo, sheep, goats, and horses, first, the total nitrogen was calculated by multiplying the population of each type of animal by the nitrogen content of manure per head of animal. 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 nitrogen contents of manure and the percentage of each manure management category, the default values given in the *Revised 1996 IPCC Guidelines* were used. For the population size per type of livestock, the same values used in the calculation of CH_4 emissions were used.

Table 6-26 Amounts of nitrogen in manure excreted by buffalo, sheep, goats, and horses

Type of animal	[kg-N/head/year]
Buffalo	40*
Sheep	12
Goats	40*
Horses	40*

Source: *Revised 1996 IPCC Guidelines*, Vol. 3, page 4.99, Table 4-20 (Reference 3)
* Value of "Other animals"

Table 6-27 Percentage of each manure management category for buffalo, sheep, goats, and horses

Treatment category		Percentage of treatment			
		Buffalo	Sheep	Goats	Horses
11. Anaerobic lagoons		0%	0%	0%	0%
12. Liquid systems (pit storage)		0%	0%	0%	0%
13. Solid storage and dry lot (sun drying)		14%	0%	0%	0%
14. Other	h. Daily spread	16%	0%	0%	0%
	i. Pasture, range and paddock	29%	83%	95%	95%
	j. Used as fuel	40%	0%	0%	0%
	k. Other system	0%	17%	5%	5%

Source: *Revised 1996 IPCC Guidelines*

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 and N_2O from each livestock, 100%—the concerned or similar sources given in the *GPG (2000)*—were applied in accordance with the decision tree for uncertainty assessment. For the uncertainty of the activity data in each livestock, 100% was applied in accordance with decision tree. As a result, the uncertainties of the emissions were determined to be 141% for each livestock. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

For emission factors, same values were used consistently for all the years. Activity data were calculated consistently for all the years from the data in the *Statistical Document of Livestock Breeding,* the *Statistical Document of Horse* and the L*ivestock Statistics of Okinawa*.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e） Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions of buffalo for FY2011 were revised in accordance with the revision and/or update of population of buffalo for FY2012.

f） Source-specific Planned Improvements

There is a need to discuss whether Japan's country-specific emission factors will be established on the basis of actual measurements.

6.3.3. Camels and Llamas, Mules and Asses (4.B.5., 4.B.7.)

Japan reported "NO" in this section as these animals were not likely to be raised for agricultural purposes.

6.3.4. Other (4.B.10.)

The only livestock that are bred in Japan are cattle, buffalo, sheep, goats, horses, swine and poultry. Therefore, this category has been reported as "NO".

6.4. Rice Cultivation (4.C.)

CH_4 is generated under anaerobic conditions by the action of microbes. Therefore, paddy fields provide favorable conditions for CH_4 generation. 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 FY2012 are 5,480 Gg-CO_2 eq., comprising 0.4% of total emissions (excluding LULUCF). The value represents a reduction by 21.3% from FY1990.

Table 6-28 CH_4 emissions from rice cultivation

Gas	Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CH_4	4.C.1.- Intermittently flooded	Gg-CH_4	319.9	325.5	272.1	263.8	257.3	254.8	251.7	250.9	251.9
	4.C.1.- Continuously flooded	Gg-CH_4	11.6	11.8	9.8	9.5	9.3	9.2	9.1	9.1	9.1
	Total	Gg-CH_4	331.4	337.3	281.9	273.3	266.6	264.0	260.8	260.0	261.0
		Gg-CO_2eq	6,960	7,083	5,920	5,739	5,599	5,545	5,477	5,460	5,480

6.4.1. Intermittently Flooded (Single Aeration) (4.C.1.-)

a）Source/Sink Category Description

This section provides the estimation methods for CH_4 emissions from intermittently 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 *Revised 1996 IPCC Guidelines*. The diagram below presents the outline.

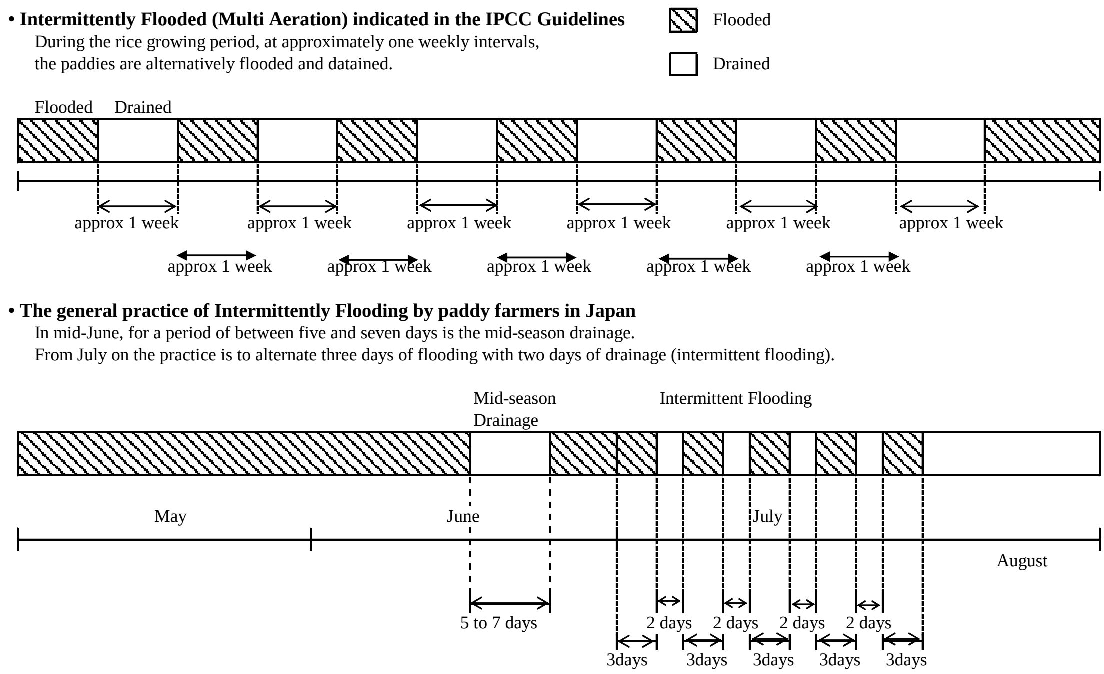

Figure 6-4 Comparison of water management regime in Japan and intermittent flooding (multi aeration) indicated in the *IPCC Guidelines*

b）Methodological Issues

- ***Estimation Method***

CH_4 emissions from intermittently flooded paddy fields (single aeration) were calculated by taking the overall usage of organic matter management into account, since the actual measurements of emission factors per soil type for each type of organic matter management (type of applied organic matter) existed.

The amount of CH_4 generated per type of soil for each method of organic matter management was calculated by multiplying the area of intermittently flooded paddy fields by the "amount of CH_4 generated per type of soil per unit area for each management method", "proportion of the area of each type of soil", and "proportion of each organic management method".

CH_4 emission from intermittently flooded paddy fields (single aeration) [kg-CH_4]
= ∑ (Emission factor for organic matter management method *n* for soil type *m* [kg-CH_4/m^2]
× Area of paddy fields [m^2] × Percentage of intermittently flooded paddy field
× Proportion of soil type *m* × Proportion of organic matter management method *n*)

- ***Emission Factors***

The following table summarizes the emission factors established for each category of this source.

The established emission factors are based on actual measurements of five soil types, with and without straw amendment. Actual data on soil types subject to composting is not available, but the CH_4 emission of composted soil is 1.2 to 1.3 times of un-composted soil. Therefore, the emission factor for composted soil, by soil type, was established as 1.25 times larger than the value for un-composted soil.

Table 6-29 CH_4 emission factor for intermittently flooded paddy fields (single aeration)

Type of soil	Straw amendment [g-CH_4/m²/year]	Various compost amendment [g-CH_4/m²/year]	No-amendment [g-CH_4/m²/year]
Andosol	8.50	7.59	6.07
Yellow soil	21.4	14.6	11.7
Lowland soil	19.1	15.3	12.2
Gley soil	17.8	13.8	11.0
Peat soil	26.8	20.5	16.4

Source: Haruo Tsuruta (2000) (Reference 31)

- ***Activity Data***

It is assumed that intermittently flooded paddy fields (single aeration) comprise some 98% of planted paddy area and continuously flooded paddies comprise the remaining 2%[1].

The method of establishing activity data for emissions of CH_4 from intermittently flooded paddy fields (single aeration) was to multiply the planted paddy area given in the Ministry of Agriculture, Forestry and Fisheries in *Statistics of Cultivated and Planted area*, by the proportion of area by each soil types (Takata et al.. (2009)), and then by the proportion subject to organic matter management. Since the survey for proportion of organic matter management has been conducted every year since FY2008, their data has been reflected to the estimation.

Table 6-30 Proportion of Japan's surface area represented by specific soil types

Soil type		~1991	1992	1997	2001	2002~
Andosol	Andosol, moist andosol, andosol gley soil	13.06%	**13.06%**	13.14%	**13.20%**	13.20%
Yellow soil	Brown forest soil, gray ground soil, gley ground soil, yellow soil, dark red soil, red soil, lithosol	11.31%	**11.31%**	11.03%	**10.80%**	10.80%
Lowland soil	Brown lowland soil, grey lowland soil, regosol	40.82%	**40.82%**	40.62%	**40.46%**	40.46%
Gley soil	Gley soil, strong gley soil	28.94%	**28.94%**	29.20%	**29.40%**	29.40%
Peat soil	Black peat, peat soil	5.85%	**5.85%**	6.02%	**6.15%**	6.15%

*1992 data and 2001 data were original data indicated in Takata et al..(2009). 1993-2000 data were calculated by using interpolation between 1992 and 2001. 1992 data was used for data before FY1991 and 2001 data was used for data after FY2002.

Source: Calculated from Takata et al..(2009) (Reference 48)

[1] *Revised 1996 IPCC Guidelines,* vol.2 Workbook, p4.18, Table 4.9

Table 6-31 Proportion of organic matter management in Japan

Organic matter	1990~2007	2008	2009	2010	2011	2012
Straw amendment	60%	65%	61%	57%	62%	65%
Various compost amendment	20%	18%	23%	26%	22%	23%
No-amendment	20%	17%	16%	17%	16%	12%

Source : 1990～2007: MAFF, *"Basis Survey of Soil Environment"* (Reference 49)
After 2008: MAFF, " Survey of Greenhouse Gas Emissions from Soils and Soil Carbon Sequestration" (Reference 50)

Table 6-32 Area of paddy fields

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Area of paddy field	kha	2,055	2,106	1,763	1,702	1,624	1,621	1,625	1,574	1,579	1,597

Source: *Statistics of Cultivated and Planted Area* (MAFF) (Reference 13)

c） Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties for CH_4 emissions from intermittently flooded (single aeration) paddy fields are assessed with respect to each organic matter management method (straw amendment, various compost amendment and no-amendment), because the uncertainty assessment methods differ for each management regime.

For the uncertainties of the emission factors the values given in the *GPG (2000)* or the values calculated by expert judgment were applied in accordance with the decision tree for uncertainty assessment. For the uncertainty of the activity data, 0.31% 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 32% for straw amendment, 32% for various compost amendment and 46% for no-amendment. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e） Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f） Source-specific Planned Improvements

The MAFF is currently conducting a comprehensive study aimed at agricultural land. A part of results of this study were reflected for estimation in this year. There will be a review to be conducted on the estimation methods and parameter when new results of the study become available.

Work is progressing on developing an estimation method that uses the DNDC model, and the application of Tier 3 will be discussed in the future.

6.4.2. Continuously Flooded (4.C.1.-)

a） Source/Sink Category Description

This section provides the estimation methods for CH_4 emissions from continuously flooded rice cultivation.

b） Methodological Issues

- ***Estimation Method***

CH_4 emissions have been calculated by using country-specific emission factors for different soil types and for different organic amendments, in accordance with decision tree of the *GPG (2000)* (Page 4.79, Fig. 4.9).

- ***Emission Factors***

Research results in Japan (Association for Advancement of Agricultural Science (2000), Reference 28) indicate that emissions of CH_4 from intermittently flooded paddy fields are 42% to 45% less than those from continuously flooded paddy fields. This knowledge formed the basis for the establishment of an emission factor for CH_4 from continuously flooded paddy fields: divide the implied emission factor, which is gotten by divided emissions by crop field area, for intermittently flooded paddy fields by 0.565 (1-0.435). Since proportion of area by soil types and proportion of organic matter management change every year, the implied emission factor for intermittently flooded paddy fields changes every year. Therefore, the emission factor for continuously flooded paddy fields changed annually.

Table 6-33 Emission factor for CH_4 from continuously flooded paddy fields

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Continuously flooded paddy fields	g-CH_4/m^2/year	28.12	28.12	28.12	28.12	28.62	28.38	28.05	28.46	28.87	28.87
Intermittently flooded paddy fields (single aeration)*	g-CH_4/m^2/year	15.89	15.89	15.89	15.89	16.17	16.04	15.85	16.08	16.31	16.31

* Implied emission factor

- ***Activity Data***

It is assumed that intermittently flooded paddy fields (single aeration) comprise some 98% of planted paddy area and continuously flooded paddies comprise the remaining 2%.

The method of establishing activity data for emissions of CH_4 from continuously flooded paddy fields was to multiply the planted paddy area given in the MAFF in *Statistics of Cultivated and Planted area*, by 2%.

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainties for emission factors were calculated from the uncertainties of each parameter decided by expert judgment. For the uncertainty for activity data, 0.31% of standard error for area of paddy field given in the *Statistics of Cultivated and Planted Area* was applied. As a result, the uncertainty of the emissions was determined to be 116%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Refer to section *6.4.1. Intermittently Flooded*.

d） Source-specific QA/QC and Verification

Refer to section *6.4.1. Intermittently Flooded*.

e） Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f） Source-specific Planned Improvements

Japan's CH_4 emission ratio of "Intermittently flooded / continuously flooded" are measured on only one site; therefore, further data collection is regarded as necessary.

6.4.3. Rainfed & Deep Water (4.C.2., 4.C.3.)

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".

6.4.4. Other (4.C.4.)

Just as indicated in the *World Rice Statistics 1993-94*, IRRI, a possible source of emissions in this category is upland rice field, but since upland rice field are not flooded, like the soil of fields, they are aerobic and do not become anaerobic. The bacteria that generate CH_4 are obligatory anaerobic bacterium, and unless the soil is maintained in an anaerobic state, there will be no generation of CH_4. As generation of CH_4 is not feasible, this category was reported as "NA".

6.5. Agricultural Soils (4.D.)

This section provides the estimation methods for N_2O direct emissions from soils (by applied synthetic fertilizers, organic fertilizers, nitrogen fixation by N-fixing crops, crop residue and plowing of organic soil), and for N_2O indirect emissions (by atmospheric deposition and nitrogen leaching and run-off).

- ***Direct Emissions (N_2O)***

Application of synthetic fertilizers, organic fertilizers, nitrogen fixation by N-fixing crops or use of crop residues for soil amendment 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 emitted via denitrification of nitrate. N_2O is generated when organic soil containing nitrogen is plowed.

- ***Indirect Emissions (N_2O)***

Nitrogen compounds such as ammonia, that volatilize and are released into the atmosphere from synthetic fertilizers applied to agricultural soils and organic fertilizers derived from livestock manure 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 and manure-derived fertilizers applied to agricultural soil.

N_2O emissions from agricultural soils in FY2012 are 6,140 Gg-CO_2 eq., comprising 0.5% of total emissions (excluding LULUCF). The value represents a reduction by 26.7% from FY1990.

Table 6-34 N_2O emissions from agricultural soils

Gas	Item		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
N_2O	4.D.1. Direct emission	Synthetic fertilizers	Gg-N_2O	6.2	5.4	4.9	4.8	4.1	3.9	4.0	4.1	4.0
		Organic fertilizers	Gg-N_2O	5.9	5.5	5.2	4.8	4.7	4.6	4.6	4.6	4.5
		N-fixing crops	Gg-N_2O	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2
		Crop residue	Gg-N_2O	1.9	1.9	1.8	1.7	1.7	1.6	1.6	1.5	1.5
		Plowing of organic soil	Gg-N_2O	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	4.D.2. Pasture, range and paddock manure		Gg-N_2O	0.22	0.21	0.20	0.17	0.16	0.16	0.16	0.16	0.16
	4.D.3. Indirect emission	Atmospheric deposition	Gg-N_2O	5.1	4.8	4.4	4.2	4.0	3.9	3.9	4.0	3.9
		Nitrogen leaching and run-off	Gg-N_2O	7.0	6.4	5.9	5.6	5.1	4.9	5.0	5.0	5.0
	Total		Gg-N_2O	27.0	24.8	23.1	21.9	20.4	19.8	19.8	20.0	19.8
			Gg-CO_2eq	8,377	7,702	7,147	6,780	6,324	6,133	6,144	6,185	6,140

6.5.1. Direct Soil Emissions (4.D.1.)

6.5.1.1. Synthetic Fertilizers (4.D.1.-)

a） Source/Sink Category Description

This section provides the estimation methods for N_2O emissions by the application of synthetic fertilizers.

b） Methodological Issues

- ***Methodology for Estimating Emissions / Removals of GHGs***

N_2O emissions were calculated, using country-specific emission factors in accordance with decision tree of the *GPG (2000)* (Page. 4.55 Fig. 4.7).

$$E = \sum (A_i \times EF_i \times 44/28)$$

E : N_2O emissions associated with the application of synthetic fertilizer in agricultural soil (crop field) [kg-N_2O]

A_i : Nitrogen amount of synthetic fertilizer applied to agricultural soil for crop type i [kg-N]

EF_i : Emission factor for crop type i [kg-N_2O-N/kg-N]

- ***Emission Factors***

Emission factors were established based on actual data measurement conducted in Japan.

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 *Revised 1996 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.

Table 6-35 N_2O emission factor for synthetic fertilizer to agricultural soil

Crop species	Emission Factor [kg-N_2O-N/kg-N]
Paddy rice	0.31 %
Tea	2.9 %
Other species	0.62 %

Source: Akiyama et al., *Direct N_2O emissions and estimate of N_2O emission factors from Japanese agricultural soils.* (2006) (Reference 39)

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 40)

- ***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 6-36).

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.

$$A_i = (A_T - A_{FRST}) \times \frac{(RA_i \times RF_i / 10)}{\sum (RA_n \times RF_n / 10)}$$

A_i : Nitrogen amount of synthetic fertilizer applied to agricultural soil for crop type i [t-N]

A_T : Total nitrogen amount of synthetic fertilizer [t-N]

A_{FRST} : Nitrogen amount of synthetic fertilizer applied to forest [t-N]

RA_i : Area of crop field for crop type i [t-N]

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 [t-N]

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 (*A report on an Investigation of how to quantify the amount of Greenhouse Gases Emissions reduced in 2000 F.Y.* (Reference 28)). 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 28) 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 45) 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 6-36). 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.

Table 6-36 Nitrogen amount of synthetic fertilizer applied to soil

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Total N amount of synthetic fertilizer	t-N	611,955	527,517	487,406	471,190	360,056	350,135	403,901	387,201	387,201	387,201
N amounut of synthetic fertilizer applied (forest soil)	t-N	288	248	229	222	157	165	190	182	182	182
N amounut of synthetic fertilizer applied (agricultural soil)	t-N	611,667	527,269	487,177	470,968	359,899	349,970	403,711	387,019	387,019	387,019

Source: Total: *Yearbook of Fertilizer Statistics (Pocket Edition)* (References 17)

Applied to forest: Forest Agency Survey

Table 6-37 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, *Establishment of GHGs reduction model, Incorporated foundation* (References 28)

Table 6-38 Amount of synthetic fertilizers application per area (rice and tea)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Amount of synthetic fertilizers application per area (rice)	kg-N/10a	9.65	8.71	7.34	6.62	6.47	5.80	5.95	5.94	5.94	5.94
Amount of synthetic fertilizers application per area (tea)	kg-N/10a	57.23	54.88	48.06	44.76	44.76	44.76	44.76	44.76	44.76	44.76

Source: Rice: *Yearbook of Fertilizer Statistics (Pocket Edition)* (References 17)

Tea: Kunihiko Nonaka (2005) (References 45)

Table 6-39 Area of cropping by each type of crop

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Vegetables	kha	620.1	564.4	524.9	476.3	469.5	468.7	465.4	460.4	457.9	457.9
Paddy rice	kha	2,055.0	2,106.0	1,763.0	1,702.0	1,624.0	1,621.0	1,625.0	1,574.0	1,579.0	1,597.0
Fruit	kha	346.3	314.9	286.2	265.4	254.7	250.7	246.9	243.5	240.3	240.3
Tea	kha	58.5	53.7	50.4	48.7	48.0	47.3	46.8	46.2	45.9	45.4
Potatoes	kha	115.8	104.4	94.6	86.9	84.9	83.1	82.5	81.0	81.2	81.2
Pulse	kha	256.6	155.5	191.8	193.9	199.7	197.5	189.0	186.2	180.2	180.2
Feed crops	kha	1,096.0	1,013.0	1,026.0	1,030.0	1,012.0	1,008.0	1,012.0	1,030.0	1,029.0	1,012.0
Sweet potato	kha	60.6	49.4	43.4	40.8	40.7	40.5	39.7	38.9	38.8	38.6
Wheat	kha	366.4	210.2	236.6	268.3	265.4	266.2	265.7	271.7	269.5	269.5
Coarse cereal (including buckwheat)	kha	29.6	23.4	38.4	45.9	49.1	47.5	49.7	58.1	62.6	62.6
Mulberries	kha	59.5	26.3	5.9	3.0	2.0	2.0	2.0	2.0	2.0	2.0
Industrial crops	kha	142.9	124.5	116.3	110.3	107.5	106.4	104.8	101.9	100.2	100.7
Tobacco	kha	30.0	26.4	24.0	19.1	16.8	15.8	15.0	13.0	9.0	9.0
Upland rice	kha	18.9	11.6	7.1	4.5	3.2	3.0	2.9	2.4	2.1	1.7

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***

N_2O emissions by the application of synthetic fertilizers were estimated for each crop species. Thus, the uncertainties of N_2O emissions by the application of synthetic fertilizers were also calculated for each crop species and then finally combined as total uncertainties. The uncertainties for the emission factors were calculated by combining the uncertainties of parameters, estimated by expert judgment or using sample standard deviations. As a result, the uncertainties for emission factors were determined to be 220.0% for paddy rice, 211.7% for tea, 181.7% for other crops. For the uncertainty for activity data, 0.31% for paddy rice and 0.26% for other crops (the value for area of upland fields), which is standard error given in the Statistics of Cultivated and Planted Area, was applied. As a result, the uncertainties of the emissions were determined to be 139%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1. Comparison with Japan's EF and the default EF in the IPCC Guidelines is described in the section 'Emissions factors' above.

e) Source-specific Recalculations

The amount of synthetic fertilizer applied to agricultural soil was revised (amount of synthetic fertilizer applied to forest was subtracted form total amount of synthetic fertilizer). Therefore, emissions for all years were revised. In addition, in the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2010 and FY2011 were revised in accordance with the revision and/or update of the activity data for FY2011 and FY2012.

f） Source-specific Planned Improvements

The same emission factor has been used for synthetic and organic fertilizers. Thus, it is needed to discuss whether it is possible to obtain separate emission factors for these two types of fertilizer.

6.5.1.2. Organic Fertilizer (Application of Animal Waste) (4.D.1.-)

a） Source/Sink Category Description

This section provides the estimation methods for N_2O emissions by application of organic fertilizer (livestock and other compost and barnyard manure).

b） Methodological Issues

- ***Estimation Method***

Emissions of N_2O have been calculated in accordance with decision tree of the *GPG (2000)* (Page 4.55, Fig. 4.7).

$$E = \sum (A_i \times EF_i \times 44 / 28)$$

E : N_2O emissions from the application of organic fertilizers to agricultural soils [kg-N_2O]

A_i : Nitrogen amount of organic fertilizer applied to agricultural soil for crop type *i* [kg-N]

EF_i : 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 6-33)

- ***Activity Data***

For activity data (Table 6-40), sum of "Nitrogen amount in livestock manure applied to agricultural soil (N_D)" and "Nitrogen amount applied to agricultural soil from human waste (N_{FU})" estimated in 6.5.3.1. atmospheric deposition (4. D.3-) are used. (For estimation method, see 6.5.3.1. "Atmospheric deposition")

Table 6-40 Nitrogen amount applied to agricultural soil as organic fertilizer

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Nitrogen amount in livestock manure applied to agricultural soil （N_D）	t-N	578,360	553,566	519,787	484,985	477,692	472,642	466,626	467,070	460,710	460,710
Nitrogen amount applied to agricultural soil from human waste (N_{FU})	t-N	10,394	4,747	2,116	874	1,702	457	427	369	351	351
Nitrogen amount applied to agricultural soil as organic fertilizer （N_D+N_{FU}）	t-N	588,754	558,313	521,903	485,858	479,393	473,099	467,053	467,439	461,061	461,061

To disaggregate these nitrogen amount 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 45) 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 6-39). Area of cultivated land by type of crop is same as synthetic fertilizers.

$$A_i = (N_D + N_{FU}) \times \frac{(RA_i \times RF_i / 10)}{\sum (RA_n \times RF_n / 10)}$$

A_i : Nitrogen amount of organic fertilizer applied to agricultural soil for crop type *i* [t-N]
N_D : Nitrogen amount in livestock manure applied to agricultural soil [t-N]
N_{FU} : Nitrogen amount applied to agricultural soil from human waste [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 6-41 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: *Association for Advancement of Agricultural Science, A report on an Investigation of how to quantify the amount of Greenhouse Gases Emissions reduced in 2000 F.Y.. (Reference 28)*

Table 6-42 Amount of nitrogen as organic fertilizers application per area for tea

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Amount of organic fertilizers application per area (tea)	kg-N/10a	20.77	19.92	17.44	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 45)*

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

An uncertainty assessment was conducted by the same method as in 6.5.1.1. Synthetic Fertilizers. As a result, the uncertainty of the emissions was determined to be 152%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e) Source-specific Recalculations

Nitrogen amount in livestock manure applied to agricultural soil (N_D) were revised. Therefore, emissions for all years were revised. In addition, in the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the area data for FY2012.

f) Source-specific Planned Improvements

The same emission factor has been used for synthetic and organic fertilizers. Thus, it is needed to discuss whether it is possible to obtain separate emission factors for these two types of fertilizer.

6.5.1.3. N-fixing Crops (4.D.1.-)

a) Source/Sink Category Description

This section provides the estimation methods for N_2O emissions from nitrogen fixed by N-fixing crops.

b) Methodological Issues

- ***Estimation Method***

Emissions are calculated by taking the amount of nitrogen fixed by nitrogen-fixing crops, which is estimated using Japan's observation data, and multiplying by country-specific emission factor.

$$E = EF \times F_{BN} \times 44/28$$

E : N_2O emission associated with N-fixation by N-fixing crops [kg-N_2O]
EF : Emission factor [kg-N_2O- N/kg-N]
F_{BN} : Amount of nitrogen fixed by N-fixing crops [kg-N]

- ***Emission Factors***

The N_2O emission factor for emissions from application of synthetic fertilizer, which is set using Japan's measurement results, is set on the basis of emissions from both nitrogen from fertilizer application and the amount of nitrogen fixed by nitrogen-fixing crops. Therefore, it is set as the emission factor of N_2O emissions from nitrogen fixed by N fixing crops. Although there are three kinds of emission factors for synthetic fertilizers, such as for "rice", "tea", and "other crops", (see Table 6-36), the EF of "other crops" (0.0062 [kg-N_2O-N/kg-N]) is applied in view of the target crops.

- ***Activity Data***

The amount of nitrogen in the above-ground part biomass of N fixing crops is considered to be reasonably substituted for the amount of annual nitrogen fixation by the N fixing crops cultivated in one year. The nitrogen content data in the harvest in the crops and a harvest residue of our country in Owa (1996) was used, and the nitrogen amounts fixed by N fixing crops are calculated by the following methods. The target crops are broadly classified into "Pulse (dried grain) and vegetables", and "feed crops."

➢ ***Pulse (dried grain) and Vegetables***

Included in calculations for nitrogen-fixing crops are the pulses (dried seeds) of soybeans, adzuki beans, kidney beans, and peanuts, and the vegetables of string beans, snow peas, broad beans, and green soybeans.

The amount of nitrogen fixed by nitrogen-fixing crops (F_{BN}) was set by transforming Tier 1b Equation 4.26 of GPG (2000) and multiplying the crop yield for N-fixing crops ($Crop_{BFi}$) by the amount of nitrogen per crop yield and crop residue, which was determined by Japanese research data.

$$F_{BN} = \sum_i \left[Crop_{BFi} \times (Frac_{NCRBFi} + Frac_{NRESBFi}) \right]$$

F_{BN} : The amount of nitrogen fixed by N-fixing crops [kg-N]

$Crop_{BFi}$: Actual crop yield for N-fixing crops *i* [t]

$Frac_{NCRBFi}$: Amount of nitrogen per crop yield for N-fixing crops *i* [kg-N/t]

$Frac_{NRESBFi}$: Amount of nitrogen per crop residue for N-fixing crops *i* [kg-N/t]

- ***Feed crops***

In Japan, grass and legume feed crops are sown together. Statistical information enables one to ascertain only the crop yield and planted areas of grass-only feed crops and mixed grass–legume feed crops. Because that makes it impossible to directly find the harvest amount and planted area of legume-only feed crops, for the sake of convenience, it is used 10% for the proportion of legume feed crops in mixed-sown in accordance with the judgments of experts based on a Japanese study[2] and other sources, and estimated the crop yield of legume feed crops.

Japanese research data include those on the nutrient content in the stubble and roots of grass–legume mixed feed crops, and taking into account that calculations for nitrogen-fixing crops in the *2006 IPCC Guidelines* cover the amount of aboveground biomass residue and underground biomass plowed into soil, it was decided that calculation of the nitrogen amount fixed by legume feed crops would directly use the amount of nitrogen in stubble and root residue instead of the amount of nitrogen in harvested aboveground biomass, and estimates were made with the following equation, obtained by transforming *GPG (2000)* Equation 4.27.

$$F_{BN} = \sum_i \left[Crop_{BF} \times Frac_{NCBGF} \right]$$

F_{BN} : Amount of nitrogen fixed by leguminous feed crops [kg-N]

$Crop_{BF}$: Actual crop yield for leguminous feed crop [t]

$Frac_{NCBGF}$: Amount of nitrogen contained in the underground part per crop yield for leguminous feed crop [kg-N/t]

Table 6-43 Parameters used in estimating for N-fixing crops

Type of crop	Amount of fixed nitrogen per unit crop yield [kg-N/t]	Proportion of dry matter
Soybeans	69.17	1.000
Adzuki beans	40.68	1.000
Kidney beans	50.13	1.000
Peanuts	63.00	1.000
Strings beans	1.98*2	0.302*1
Snow pea	2.65*2	0.302*1
Broad beans	9.57*1	0.302*1
Green soybeans	9.57	0.302
Leguminous feed crop	2.74	0.200

*1 The value for green soybeans is substituted.

*2 Each crop value are calculated by using nitrogen ratio included in harvest for each crop and green soybeans and by using the

2 Research results of Hokkaido prefectural Agricultural Experiment Stations" Current status and issues of feed crop production in meadow in Hokkaido I. Current status of crop yield and nutrient value" http://www.agri.pref.hokkaido.jp/center/kenkyuseika/gaiyosho/h12gaiyo/20003161.htm

amount of fixed nitrogen per unit crop yield for green soybeans .

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

N_2O emissions for nitrogen fixed by N fixing crops were estimated for each crop species. Thus, the uncertainties of N_2O emissions for nitrogen fixed by N fixing crops were also calculated for each crop species and then finally combined as total uncertainties. The uncertainties for the emission factors were calculated by combining the uncertainties of parameters decided by expert judgment and indicated in the *GPG (2000)*. The uncertainties for activity data were determined to be 0.26% of standard error for the area of crop field indicated in the *Statistics of Cultivated and Planted Area*. As a result, the uncertainties for emission from nitrogen fixed by N fixing crops were determined to be 99%.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e） Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f） Source-specific Planned Improvements

The percentage of legume feed crops in mixed-sown pastures is needed to be elaborated. To make the shift to the estimation method in accordance with the *2006 IPCC Guidelines* in the future, it is a need to obtain data of underground crop residue plowed into soil. But sufficient their data don’t exist now. These improvement are investigation issues in the future.

6.5.1.4. Crop Residue (4.D.1.-)

a） Source/Sink Category Description

This section provides the estimation methods for N_2O emissions by crop residue plowed into soil.

b） Methodological Issues

- ***Estimation Method***

N_2O emissions associated with the application of crop residues to agricultural soils were calculated by multiplying the default emissions factors given in the *Revised 1996 IPCC Guidelines* by the nitrogen input through the use of crop residues plowed into soil.

N_2O emission associated with the use of crop residues plowed into soil [kg-N_2O]
= Default emission factor [kg-N_2O-N/kg-N]
× Nitrogen input through the use of crop residues plowed into soil [kg-N] ×44/28

- ***Emission Factors***

The default emission factor, 0.0125 [kg-N_2O-N/kg-N], shown in the *Revised 1996 IPCC Guidelines* and the *GPG (2000)* was used.

- ***Activity Data***

[Rice]

For the amount of rice crop residue plowed into soil, the data for rice straw and rice chaff indicated in the survey of MAFF 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).

[Wheat, Barley]

The total amount of nitrogen in residue for wheat and barley was calculated by multiplying the amount of crop production (by MAFF, '*Statistics of Cultivated and Planted Area*' or '*Vegetable Production and Shipment Statistics*') by nitrogen content in residue per crop production calculated from Matsumoto (2000). Amount of nitrogen in residue plowed into soil was calculated by multiplying the total amount of nitrogen in residue by the proportion of the amount of nitrogen in residue plowed into soil estimated from crop area of each treatment for wheat straw surveyed by MAFF.

[Crops other than rye (for grain), oats (for grain) and Tea]

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*) by the ratio other than burned in the field (burned in the field: 0.1, the default value in the *Revised 1996 IPCC Guidelines*).

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 sweet potato and 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. For feed crops, the area not plowed into soil was excluded. For the crops which were assumed that field burning is not practiced in Japan, and which were not included in the calculation for the field burning of crop residues (4.F), "Proportion burned in field" were considered as "zero".

Amount of nitrogen in crop residue plowed into soil [kg-N] (rice (rice straw and rice chaff))
＝Annual amount of residue plowed into soil [t] × Nitrogen content in crop residue [kg-N/t]

Amount of nitrogen in crop residue plowed into soil [kg-N] (wheat and barley)
＝ Σ_{crop}{ Annual crop production [t]
× Proportion crop residue plowed into soil per crop production [%]
× Nitrogen content in residue per crop production [kg-N/t]}

Amount of nitrogen in crop residue plowed into soil [kg-N] (crops other than rye, oats, tea, rice, wheat and barley)
＝ Σ_{crop}{ Annual crop production [t] × Nitrogen content in residue per crop production [kg-N/t]
× (1－Proportion burned in field)}

Table 6-44 Residue/crop production ratio, nitrogen content in residue and nitrogen content in residue per crop production for main crops

Crop type	Residue /Crop production ratio [t (residue)/ t (crop yield)] (A)	Nitrogen content in residue [kg-N/t (residue)] (B)	Nitrogen content in residue per crop production [kg-N/t (crop yield)] (A)×(B)	Note
Rice (straw)	-	5.41 [e]	-	Wet weight
Rice (chaff)	-	4.23 [e]	-	
Barley	1.39 [a]	3.68 [a]	0.511	
Wheat	1.39 [a]	3.68 [a]	0.511	
Soy	1.40 [a]	10.9 [a]	15.19	
Potatoes	0.0321 [d]	2.22 [b]	0.71	
Sweet potatoes	0.808 [c]	2.29 [c]	1.85	
Sugarbeets	0.0617 [d]	15.4 [b]	0.95	
Sugarcane	0.102 [c]	5.48 [c]	0.56	
Maize	1.20 [a]	3.52 [a]	4.22	
Japanese radish	0.033 [d]	2.84 [b]	0.93	
Chinese cabbage	0.018 [d]	4.03 [d]	0.71	
Cabbage	0.672 [a]	2.72 [a]	1.83	
Lettuce	0.040 [d]	4.08 [d]	1.64	
Onion	0.015 [d]	1.24 [b]	0.019	

a: Matsumoto N., *Development of Estimation Method and Evaluation of Nitrogen Flow in Regional Areas* (2000) (Reference 55)

b: Hokkaido Government, *Hokkaido Fertiliser Recommendations 2010*. (2010) (Reference 56)

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 33)

e: Date N., *"Handbook for Organic Fertilizers and Microbial Materials"*, 1988 (Reference 59)

[Rye and Oats (for grain)]

In accordance with the default technique described in the *Revised 1996 IPCC Guidelines* and the *GPG (2000)*, the amount of nitrogen applied to soil by plowing in crop residues was determined by multiplying the annual production of each type of crop by each of the percentage of residues in the production of each crop, the average percentage of dry matter in the residues, the percentage less the percentage burned in the field, and the nitrogen content in the residues (see Table 6-47).

<u>*Nitrogen plowed into soil with crop residues [kg-N] (rye and oats)*</u>
= Annual crop yield [t] × Proportion of residue to crop yield
× Average proportion of dry matter in crop residue [t-dm/t]
× (1 – Proportion burned in field) × Nitrogen content [t-N/t-dm] × 10^3

The production amount of rye and oats were calculated by multiplying the planted area by the yield per unit area. The planted area was divided into the area used for grain, for green crops and for others. However, the available statistics were not reported the category of rye for grain, (the survey has been discontinued since 1992 production) and therefore the value of the "total planted area" less the "area planted for green crops" taken from the available statistics was used as the area cultivated for grain expediently, even though the planted area in this report covers the planting for grain only.

Table 6-45 Planted area of rye and oats (for grain)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Rye	kha	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1
Oats	kha	4.0	2.5	1.6	0.8	0.6	0.5	0.5	0.5	0.8	0.8

Source: The data are calculated by using the *Statistics of Cultivated and Planted Area* (MAFF) (Reference 13)

Table 6-46 Yields of rye and oats per unit area

Crop	Yield per unit area	Note
Rye	424 [kg/10a]	Data determined by specialists based on the results of rye cultivation tests in Japan
Oats	223 [kg/10a]	Data available only up to FY1994. The 1994 figures were used for all fiscal years since most of the data before 1994 were available for major prefectures only.

Table 6-47 Proportion of residue to crop production, average proportion of dry matter in crop residues, nitrogen content

Crop	Proportion of residue	Average proportion of dry matter in residue	Nitrogen content	Proportion burned in field
Rye	2.84	0.90	0.0048	See Table 6-60
Oats	2.23	0.92	0.0070	See Table 6-60
Source	Expert Judgment	*GPG (2000)*, p. 4.58, Table 4.16		*Calculated from MAFF survey*

[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.

Nitrogen plowed into soil with crop residues [kg-N] *(Tea)*
＝(Nitrogen amount included in residue by autumn pruning [kg-N/10a]
＋Nitrogen amount included in residue by leaf fall [kg-N/10a]) ×10×Cultivated area of tea [ha]
+ Nitrogen amount included in the residue by medium pruning [kg-N/10a]×10×1/5
×Cultivated area of tea [ha]

Table 6-48 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 51), Kinoshita et al.. (2005) (Reference 52), Tachibana et al.. (1996) (Reference 53)
Medium pruning	Once in five years	19.4	Ohta et al.. (1996) (Reference 54)
Leaf fall	Annual	11.5	Hoshina et al..(1982) (Reference 51)

c) Uncertainties and Time-series Consistency

● Uncertainties

Because the estimation methods differ from one crop to the other, their uncertainties were calculated for respective crops.

The uncertainties of emission factors for crops other than rye and oats were assessed for each crop by combining the uncertainties for each parameter calculated by expert judgment and given for standard values in the *GPG (2000)*. The uncertainties of emission factors for rye and oats were calculated to combine each parameter determined by expert judgment or standard values in the *GPG (2000)*, and were determined to be 388% for rye and 392% for oats.

The uncertainties for activity data were assessed as 0.26% for tea and 0.31% for other crops by applying the standard errors in the *Crop statistics* and the *Statistics of Cultivated and Planted Area*, respectively.

As a result, the uncertainty of the emission combined from each crop uncertainty was determined to be 211%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials.

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） Source-specific Recalculations

In addition, in the agriculture sector, a 3-year average has been used. Thus, the emissions from FY 2010 to FY2011 were revised in accordance with the revision and/or update of the activity data from FY 2011 to FY2012.

f） Source-specific Planned Improvements

It is needed to discuss whether it will be possible to establish country-specific emission factors for Japan.

6.5.1.5. Plowing of Organic Soil (4.D.1.-)

a） Source/Sink 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 and upland field by the emission factor in accordance with the *Revised 1996 IPCC Guidelines* and the *GPG (2000)*.

N_2O emission associated with the plowing of organic soil [kg-N_2O]
= Emission factor for plowing of organic soil [kg-N_2O/ha] × Area of plowed organic soil [ha] × 44/28

- ***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 GPG(2000) p4.60 Table4.17. Therefore, default value is used for upland field.

- ***Activity Data***

The area of plowed organic 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. The percentage of organic soils was used data made from Takata et al..(2009)

Table 6-49 Percentage of organic soil

Soil type	~1991	1992	1997	2001	2002~
Paddy field	5.85%	**5.85%**	6.02%	**6.15%**	6.15%
Upland field	1.94%	**1.94%**	2.01%	**2.07%**	2.07%

*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 48)

Table 6-50 Areas of organic soil

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Area of organic soil (paddy field)	kha	166.5	163.3	161.5	157.2	154.7	154.1	153.5	152.2	151.8	151.6
Area of organic soil (field)	kha	24.7	24.3	24.4	24.3	24.2	24.2	24.2	24.1	24.1	24.0

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

N_2O emissions by plowing of organic soil were calculated in two category, paddy field and upland field. Therefore, the uncertainties were also calculated separately, and finally two uncertainties were combined as total uncertainty.

The uncertainties for emission factors were calculated aggregating the uncertainties of each parameter given in the *GPG (2000)* and references or calculated from the data of references. The combined uncertainties for emission factor were determined to be 248% for paddy field and 900% for upland field. For the uncertainty for activity data, 0.11% of the standard error for paddy rice and 0.26% of the standard error for upland field crops given in the *Statistics of Cultivated and Planted Area* were applied. As a result, the uncertainties of the emissions were determined to be 712%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d）Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e）Source-specific Recalculations

No recalculations.

f）Source-specific Planned Improvements

For paddy fields, country-specific emission factors are used. However, there are issues such as the exclusion of influence for stubble which remains in the ground surface after harvest and the influence of the plowing of straw residue, to avoid double counting of emissions. It is necessary to promote further elaborate check to reflect more suitable national condition to the emission factor, including upland field which use default emission factor.

6.5.1.6. Direct Emissions (CH_4)

CH_4-generating bacteria are absolutely anaerobic, and if soil is not maintained in an anaerobic state, CH_4 generation is not possible. Upland soils are normally oxidative and in aerobic condition. Therefore, CH_4 is not produced by these soils. For that reason, direct emission of CH_4 from soil has been reported as “NA”.

6.5.2. Pasture, Range and Paddock Manure (4.D.2.)

The method for calculating CH_4 and N_2O emissions from pasture, range, and paddock cattle manure is described in 6.3.1 “Livestock Waste Management: Cattle, Swine and Poultry (4.B.1., 4.B.8., 4.B.9.)” (see 6.3.1). N_2O emissions are counted in 4.D.2.

6.5.3. Indirect Emissions (4.D.3.)

6.5.3.1. Atmospheric Deposition (4.D.3.-)

a）Source/Sink 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 fertilizer or domestic livestock manure.

b）Methodological Issues

- ***Estimation Method***

N_2O emissions have been calculated in accordance with decision tree of the *GPG (2000)* (Page 4.69, Fig. 4.8).

Calculation of N_2O emissions associated with atmospheric deposition
Emissions of N_2O from atmospheric deposition [kg-N_2O] = emission factor [kg-N_2O-N/(kg-NH_3-N+NO_X-N)] × Total amount of nitrogen volatilized from ammonia and nitrogen oxides from livestock manure and synthetic fertilizers [kg-NH_3-N+NO_X-N] × 44/28

- ***Emission Factors***

The default value given in the Revised 1996 IPCC Guidelines has been used as the emission factor for this source.

Table 6-51 Emission factor for N_2O emissions associated with atmospheric deposition

	Emission Factor [kg-N_2O-N/(kg-NH_3-N + NO_X-N deposited)]
N_2O emissions associated with atmospheric deposition	0.01

Source: *Revised 1996 IPCC Guidelines* Vol.2 Table 4-18 (*GPG (2000)* Table4.18) (Reference 3)

- ***Activity Data***

As described in the following equation, the activity data are composed of the "amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers applied to soil "(N_{FERT}×$Frac_{GASF}$), the "amount of nitrogen that volatilizes as ammonia and nitrogen oxides in process of livestock manure management" (N_B×$Frac_{GASM1}$), the "amount of nitrogen that volatilizes as ammonia and nitrogen oxides from livestock manure applied to soil" (N_D×$Frac_{GASM2}$), and the"amount of nitrogen that volatilizes as ammonia and nitrogen oxides from human wastes applied to soil" (N_{FU}×$Frac_{GASM2}$).

$$A = N_{FERT} \times Frac_{GASF} + N_B \times Frac_{GASM1} + N_D \times Frac_{GASM2} + N_{FU} \times Frac_{GASM2}$$

A	:Total Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers, livestock manure, and human waste [kg-NH_3-N+NO_x-N]
N_{FERT}	:Amount of nitrogen for synthetic fertilizers applied to agricultural soil [kg-N]
$Frac_{GASF}$	:Percentage of volatilization as ammonia and nitrogen oxides from synthetic fertilizers applied to agricultural soil [(kg-NH_3-N + NO_X-N)/kg-N]
N_B	:Amount of nitrogen included in livestock manure [kg-N]
$Frac_{GASM1}$	:Percentage of volatilization as ammonia and nitrogen oxides from livestock manure during treatment [(kg-NH_3-N + NO_X-N)/kg-N]
N_D	:Amount of nitrogen for livestock manure applied to agricultural soil [kg-N]
N_{FU}	:Amount of nitrogen for human waste applied to agricultural soil [kg-N]
$Frac_{GASM2}$	:Percentage of volatilization as ammonia and nitrogen oxides from nitrogen contained in livestock manure and human waste applied to agricultural soils[(kg-NH_3-N + NO_X-N)/kg-N]

➢ ***Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers applied to soil (N_{FERT} ×$Frac_{GASF}$)***

"Demand for nitrogen-based fertilizers" given in the *Yearbook of Fertilizer Statistics (Pocket Edition)*, MAFF, was used for the amount of fertilized nitrogen (N_{FERT}) (including application to forest), and the default value, indicated in Table 6-52, given in the *Revised 1996 IPCC Guidelines* was used for the percentage of volatilization ($Frac_{GASF}$).

Table 6-52 Proportion of nitrogen volatilized from synthetic fertilizers and livestock manure as ammonia or nitrogen oxides

	Value	Unit
$Frac_{GASF}$	0.1	[kg-NH_3-N + NO_X-N/kg of synthetic fertilizer nitrogen applied]

$Frac_{GASM}$	0.2	[kg-NH_3-N + NO_X-N/kg of nitrogen excreted by livestock]

Source: *Revised 1996 Guidelines* Vol. 2, Table 4-17 (Reference 3)

- ***Amount of nitrogen that volatilizes as ammonia and nitrogen oxides in process of livestock manure management ($N_B \times Frac_{GASM1}$)***

The amount of nitrogen that was volatilized as ammonia and nitrogen oxides in process of livestock manure management was calculated by multiplying the amount of nitrogen excreted by each type of animal by the percentage of nitrogen that was volatilized as ammonia and nitrogen oxides from livestock manure. Because the percentage of nitrogen that is volatilized as nitrogen oxides is unknown, the percentages of the volatilization of ammonia and nitrogen oxides from manure were determined together with the percentage volatilized as ammonia based on the data in the *Estimated Volatilization of Ammonia from Livestock Manure* in the *Control of Greenhouse Gas Emissions in Livestock: Summary* (by Japan Livestock Technology Association). For grazing cattle, percentage of volatilization indicated in Table 6-53 were used.

Table 6-53 Estimated percentage of volatilized ammonia from livestock manure

Type of Animal	Value
Dairy and non-dairy cattle	10%
Swine	20%
Hen and broiler	30%

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 22)

- ***Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from livestock manure applied to soil ($N_D \times Frac_{GASM2}$)***

Amount of nitrogen in manure-derived fertilizer applied to agricultural soil (N_D) 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” ($N_{inc+waa}$), and nitrogen in manure disposed directly as waste (N_{waste}) from the total nitrogen in livestock manure ($N_{Total\text{-}AW}$).

For buffalo, sheep, goats and hoses, manure amount is very little and percentages of volatilized ammonia from livestock manure in Japan are unclear. Therefore, it was considered that all manure were applied to soil excluding volatilized N_2O.

For proportion of volatilized nitrogen as ammonia or nitrogen oxides ($Frac_{GASM2}$), default value in revised 1996 IPCC Guidelines indicated in Table 6-49 above (FracGASM) was used.

$$N_D = N_{Total\text{-}AW} - N_{PRP} - N_{N2O} - N_{NH3+NOx} - N_{inc+waa} - N_{waste}$$

N_D	:Amount of nitrogen in manure-derived fertilizer applied to agricultural soil [t-N]
$N_{Total\text{-}AW}$	:Total amount of nitrogen excreted by livestock [t-N]
N_{PRP}	:Amount of nitrogen included in grazing cattle manure [t-N]
N_{N2O}	:Nitrogen in livestock manure volatilized as N_2O(excluding grazing cattle) [t-N]
$N_{NH3+NOx}$	:Nitrogen in manure volatilized as NH_3 and NO_X (excluding grazing cattle) [t-NH_3-N + NO_X-N]
$N_{inc+waa}$	:Nitrogen eliminated by “incineration” and “purification [t-N]
N_{waste}	:Amount of nitrogen in manure disposed directly as waste [t-N]

For the amount of nitrogen included in grazing cattle manure (N_{PRP}), nitrogen in livestock manure volatilized as N_2O (excluding grazing cattle) (N_{N2O}) and nitrogen eliminated by "Incineration" and "Purification ($N_{inc+waa}$), the amount calculated in 4.B. Manure management were used.

Nitrogen in manure disposed directly as waste (N_{waste}) 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 manure disposed directly as waste is stored as mixed manure of feces and urine prior to the disposal in landfill. Therefore, manure of a portion of "Mixed - pit storage" subcategory in each livestock was deemed as the manure disposed directly as waste (for hen and broiler, manure of a portion of "Feces - piling" subcategory was deemed as the manure disposed directly as waste).

The amount of nitrogen in manure disposed directly as waste (N_{waste}) 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 treated by pit storage system (mixed) were calculated from nitrogen amount in manure and manure amount treated by pit storage system (mixed) (for hen and broilers, "Feces - piling" subcategory were used).

The livestock manure that was not applied to agricultural soils but disposed directly was included in the estimation of "8.2.1. Emissions from Managed Landfill Sites (6.A.1.)"

Nitrogen content in livestock manure disposed in the direct final disposal (N_{waste})

＝Total amount of direct final disposal and treated final disposal × Average nitrogen contents in manure treated by pit storage system (mixed)

＝Total amount of direct final disposal and treated final disposal × Nitrogen amount in manure treated by pit storage system (mixed) / Manure amount treated by pit storage system (mixed)

Table 6-54 Nitrogen amount in livestock manure applied to agricultural soil (N_D)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Total nitrogen amount in animal manure （$N_{Total\text{-}AW}$）	t-N	804,985	763,498	722,424	697,456	703,717	703,758	698,346	701,332	695,225	695,225
Nigrtogen amount in manure for grazing animal （N_{PRP}）	t-N	5,881	5,688	5,411	5,864	6,032	6,094	5,953	5,928	5,800	5,800
the amount of N_2O-N released from animal (excluing Incineration method and Wastewater manage method) （N_{N2O}）	t-N	5,196	5,061	4,933	5,457	5,928	6,041	5,917	5,900	5,793	5,793
Amount of NH_3-N and NOx-N released from animal manure (excluding garazing animal)（$N_{NH3+Nox}$）	t-N	145,894	138,305	129,967	120,899	119,398	118,736	118,542	119,282	118,562	118,562
Nitrogen eliminated by Incineration and purification （$N_{inc+waa}$）	t-N	69,165	60,416	61,891	79,768	94,079	99,447	100,711	102,536	103,639	103,639
Nitrogen amount in manure disposed directly as waste （N_{waste}）	t-N	487	462	435	483	589	799	598	616	721	721
Nitrogen amount in livestock manure applied to agricultural soil （N_D）	t-N	578,360	553,566	519,787	484,985	477,692	472,642	466,626	467,070	460,710	460,710

- ***Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from human wastes applied to soil (N_{FU} × $Frac_{GASM2}$)***

Activity data of human waste was calculated by multiplying the amount of human waste-derived nitrogen calculated with *Waste Treatment in Japan* by the value of volatile rate ($Frac_{GASM}$) indicated in Table 6-52.

Table 6-55 Nitrogen returned to agricultural soil from human waste (N_{FU})

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
N applied to agricultural soil from human waste	t-N	10,394	4,747	2,116	874	1,702	457	427	369	351	351

Table 6-56 Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers, livestock manure, and human waste

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers applied to soil (N_{FERT}×$Frac_{GASF}$)	t(NH_3-N+NOx-N)	61,196	52,752	48,741	47,119	36,006	35,014	40,390	38,720	38,720	38,720
Amount of nitrogen that volatilizes as ammonia and nitrogen oxides in process of livestock manure management (N_D×$Frac_{GASM1}$)	t(NH_3-N+NOx-N)	146,482	138,873	130,510	121,497	120,019	119,367	119,160	119,899	119,167	119,167
Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from livestock manure applied to soil (N_D×$Frac_{GASM2}$)	t(NH_3-N+NOx-N)	115,672	110,713	103,957	96,997	95,538	94,528	93,325	93,414	92,142	92,142
Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from human wastes applied to soil (N_{FU}×$Frac_{GASM2}$)	t(NH_3-N+NOx-N)	2,079	949	423	175	340	91	85	74	70	70
Total amount of nitrogen that volatilizes as ammonia and nitrogen oxides from synthetic fertilizers, livestock manure, and human waste (A)	t(NH_3-N+NOx-N)	325,429	303,288	283,631	265,788	251,904	249,000	252,960	252,107	250,100	250,100

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

N_2O emissions volatilized from atmospheric deposition were calculated in two categories, nitrogen compounds derived from synthetic fertilizer and from livestock manure (including human waste). Therefore, the uncertainties were also calculated separately, and finally two uncertainties were combined as total uncertainty.

The uncertainties for emission factors were calculated by aggregating the uncertainty of each parameter, estimated by expert judgment or given as the standard values in the *GPG (2000)*. The aggregated uncertainty of emission factor was 107% for the application of synthetic fertilizer, and 71% for the application of livestock manure. For the uncertainties of the activity data for applied synthetic fertilizers, the same values as in 6.5.1.1. [Direct Soil Emission:] Synthetic Fertilizers were applied. For applied livestock manure, the uncertainties of the activity data were calculated from 6.3.1. [Manure Management:] Cattle, Swine, and Poultry. The total emissions uncertainty aggregated from all the uncertainties was 75%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e） Source-specific Recalculations

In responding to the revision of emission factors in the manure management (4.B.), the amount of livestock-origin nitrogen returns into crop field soil was changed. Therefore, emissions for this category for all the years were revised.

f） *Source-specific Planned Improvements*

It is needed to discuss the establishment of country-specific emission factors and the ratios of volatile nitrogen compounds in synthetic fertilizers.

6.5.3.2. Nitrogen Leaching and Run-off (4.D.3.-)

a） *Source/Sink 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 *GPG (2000)* (Page 4.69, Fig. 4.8), by multiplying Japan's country-specific emission factors by the amount of nitrogen that leached and run-off.

N_2O emission associated with nitrogen that leached and run-off [kg-N_2O]
= Emission factor associated with nitrogen leaching and run-off [kg-N_2O-N/kg-N]
× Nitrogen that leached and run-off [kg-N] × 44/28

● ***Emission Factors***

The N_2O emission from this source was calculated using the Japan-specific emission factor that had been established by various studies.

Table 6-57 Emission factor for N_2O emissions associated with nitrogen leaching and run-off

	[kg-N_2O-N/kg-N]
N_2O emission from nitrogen that leaches or runs off	0.0124

Source: Takuji Sawamoto et al., Evaluation of emission factors for indirect N_2O emission due to nitrogen leaching in agro-ecosystems. (Reference 35)

● ***Activity Data***

Activity data was calculated by multiplying the default value of proportion of leaching and run-off given in the *Revised 1996 IPCC Guidelines* by the amount of nitrogen in livestock manure applied to agricultural soil and synthetic fertilizer derived from atmospheric deposition.

Table 6-58 $Frac_{LEACH}$: Proportion of nitrogen applied subject to leaching and run-off

Value	Unit
0.3	[kg-N/kg-N of fertilizer or manure]

Source: *Revised 1996 IPCC Guidelines* Vol. 2, Table 4-17 (Reference 3)

c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

N_2O emissions for nitrogen leaching and run-off were calculated in two category, synthetic fertilizer and livestock manure (including human waste). Therefore, the uncertainties were also calculated separately, and finally two uncertainties were combined as total uncertainty.

The uncertainties for emission factors were calculated aggregating the uncertainties of each parameter, estimated by expert judgments or given for standard values in the *GPG (2000)*. The aggregated uncertainty for emission factor was determined to be 113% for both synthetic fertilizers and livestock manure. For the uncertainty of activity data, the same method used at "6.5.3.1. Atmospheric Deposition" was applied. As a result, the uncertainty of the emissions was determined to be 97%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. QA/QC activities are summarized in Annex 6.1.

e） Source-specific Recalculations

In responding to the revision of emission factors in the manure management (4.B.), the amount of livestock-origin nitrogen returns into crop field soil was changed. Therefore, emissions for this category for all the years were revised.

f） Source-specific Planned Improvements

Refer to the section" 6.5.3.1. Atmospheric Deposition".

6.5.3.3. Indirect Emissions (CH_4) (4.D.3.-)

Direct CH_4 emissions were zero, and indirect CH_4 emissions from crop fields were also taken as zero. Therefore, these sources have been reported as "NA".

Except for atmospheric deposition or nitrogen leaching and run-off, there is no conceivable source of CH_4 emissions from cultivated farmland soil other than direct emissions from soil, animal production, and indirect emissions. Therefore, they have been reported as "NO".

6.5.4. Other (4.D.4)

Because it is not likely that agricultural sources of CH_4 and N_2O emissions exist in Japan other than the direct soil emissions, and indirect emissions, these sources were reported as "NO" as was the case in previous years.

6.6. Prescribed Burning of Savannas (4.E.)

This source is given in the *Revised 1996 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".

6.7. Field Burning of Agricultural Residues (4.F.)

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 FY2012 are 57 Gg-CO_2 eq. and 16 Gg-CO_2 eq., comprising 0.004% and 0.001% of total emissions (excluding LULUCF), respectively. The value represents a reduction by 43.7% and 42.2% for CH_4 and N_2O from FY1990, respectively.

Table 6-59 CH_4 and N_2O emissions from field burning of agriculture residues

Gas	Item		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CH_4	4.F.1. Cereals	Wheat	Gg-CH_4	0.42	0.23	0.30	0.40	0.36	0.29	0.24	0.24	0.26
		Barley	Gg-CH_4	0.15	0.10	0.09	0.08	0.08	0.07	0.06	0.05	0.05
		Maize	Gg-CH_4	1.89	1.66	1.48	1.32	1.37	1.38	1.36	1.38	1.39
		Oats	Gg-CH_4	0.02	0.02	0.04	0.04	0.03	0.03	0.03	0.02	0.02
		Rye	Gg-CH_4	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
		Rice	Gg-CH_4	2.06	2.27	1.53	1.06	0.86	0.79	0.77	0.77	0.77
	4.F.2. Pulses	Peas	Gg-CH_4	0.008	0.006	0.005	0.004	0.004	0.004	0.004	0.004	0.004
		Soybeans	Gg-CH_4	0.08	0.04	0.08	0.07	0.08	0.08	0.08	0.08	0.07
		Adzuki beans	Gg-CH_4	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
		Kidney beans	Gg-CH_4	0.005	0.005	0.003	0.003	0.003	0.003	0.002	0.002	0.002
		Peanuts	Gg-CH_4	0.008	0.007	0.006	0.005	0.004	0.004	0.004	0.004	0.004
	4.F.3. Tubers and roots	Potatoes	Gg-CH_4	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02
		Sugarbeat	Gg-CH_4	0.06	0.06	0.06	0.06	0.06	0.06	0.05	0.05	0.05
	4.F.4. Sugarcane		Gg-CH_4	0.06	0.04	0.04	0.03	0.04	0.04	0.03	0.03	0.03
	Total		Gg-CH_4	4.8	4.5	3.7	3.1	2.9	2.8	2.7	2.7	2.7
			Gg-CO_2eq	101	94	77	65	62	58	56	56	57
N_2O	4.F.1. Cereals	Wheat	Gg-N_2O	0.006	0.003	0.005	0.006	0.005	0.004	0.004	0.004	0.004
		Barley	Gg-N_2O	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Maize	Gg-N_2O	0.027	0.024	0.021	0.019	0.020	0.020	0.020	0.020	0.020
		Oats	Gg-N_2O	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.001	0.001
		Rye	Gg-N_2O	0.00006	0.00006	0.00009	0.00008	0.00006	0.00005	0.00004	0.00004	0.00004
		Rice	Gg-N_2O	0.039	0.043	0.030	0.020	0.016	0.015	0.015	0.015	0.015
	4.F.2. Pulses	Peas	Gg-N_2O	0.0003	0.0003	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
		Soybeans	Gg-N_2O	0.003	0.002	0.003	0.003	0.004	0.004	0.003	0.003	0.003
		Adzuki beans	Gg-N_2O	0.0009	0.0008	0.0007	0.0007	0.0005	0.0005	0.0005	0.0005	0.0006
		Kidney beans	Gg-N_2O	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		Peanuts	Gg-N_2O	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	4.F.3. Tubers and roots	Potatoes	Gg-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		Sugarbeat	Gg-N_2O	0.004	0.003	0.004	0.004	0.004	0.003	0.003	0.003	0.003
	4.F.4. Sugarcane		Gg-N_2O	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	Total		Gg-N_2O	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.05	0.05
			Gg-CO_2eq	27	26	22	18	17	16	16	16	16
Total of all gases			Gg-CO_2eq	128	120	99	84	79	75	72	72	72

6.7.1. Rice, Wheat, Barley, Rye, and Oats (4.F.1.)

a) Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from field burning of agricultural residues of rice, wheat, barley, rye, and oats.

b) Methodological Issues

- ***Estimation Method***

CH_4 and N_2O emissions were calculated, using the default method indicated in the *Revised 1996*

IPCC Guidelines and the *GPG (2000)*, by multiplying the amounts of carbon and nitrogen released by field burning by the CH_4 emission factor and N_2O emission factor, respectively.

Wheat, barley, rye, and oats were cultivated either as grain or green crops. The portions of the green crops which were cultivated for use of the entire aboveground mass for cattle feed were excluded from the calculation of emissions.

CH_4 emission associated with field burning of agricultural residues[kg-CH_4]
= CH_4 emission factor [kg-CH_4-C/kg-C] × Total carbon released [kg-C] × 16/12

N_2O emission associated with field burning of agricultural residues[kg-N_2O]
= N_2O emission factor [kg-N_2O-N/kg-N] × total nitrogen released [kg-N] × 44/28

- ***Emission Factors***

The default values shown in the Revised 1996 IPCC Guidelines and the *GPG* (2000) were used.

Table 6-60 Emission factors for CH_4 and N_2O emissions associated with field burning of rice, wheat, barley, rye, and oats residues

	Value	Unit
CH_4	0.005	[kg-CH_4/kg-C]
N_2O	0.007	[kg-N_2O/kg-N]

Source: Revised IPCC Guidelines Vol.2 Table 4-16 (Reference 3)

- ***Activity Data***

[Crops other than rice]

Activity data was calculated in accordance with the default method technique shown in the *Revised 1996 IPCC Guidelines* and the *GPG (2000)*, by multiplying by the crop yield by “proportion of residue to crop yield”, “proportion of dry matter in residue”, “proportion burned in field”,” oxidation rate” and “carbon/nitrogen content of residues”.

Total carbon/total nitrogen released by field burning of agricultural residues[kg-C, kg-N]
= Annual crop yield [t] × Proportion of residue to crop yield
× Proportion of dry matter in residue [t-dm/t] × Proportion burned in field × Oxidation rate
× Carbon/nitrogen content of residues [t-C/t-dm, t-N/t-dm] × 10^3

[Rice]

For rice, amount of burning rice straw and rice chaff on crop field is surveyed by MAFF. The residues’ nitrogen content was calculated by multiplying by the aforementioned data by nitrogen content (kg-N/t) indicated in Japan’s country-specific data of nutrient balance for each crop (Date, 1988). Therefore, emission was calculated by multiplying by the crop yield by “amount of burning rice straw and rice chaff”, “proportion of dry matter in residue”, “oxidation rate” and “carbon/nitrogen content of residues”.

Total carbon/total nitrogen released by field burning of agricultural residues [kg-C, kg-N] (Rice)
＝Amount of burning rice straw and rice chaff [t]×proportion of dry matter in residue [t-dm/t]
×Oxidation rate× Carbon/nitrogen content of residues [t-C/t-dm, t-N/t-dm]×10^3

Table 6-61 Amount of burning rice straw and rice chaff on crop field

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Rice straw	kt	438.2	536.9	429.1	276.6	183.9	163.5	149.3	187.0	187.0	187.0
Rice chaff	kt	581.3	528.3	291.3	260.3	209.9	206.0	212.9	179.2	179.2	179.2
Total	kt	1,019.5	1,065.2	720.4	536.9	393.8	369.4	362.2	366.2	366.2	366.2

Reference: Survey by MAFF

- ***Annual crop yield***

[Wheat (grain), and barley (grain)]

The values reported in the *Crop Statistics* were used for the yield of wheat, and barley (grain).

- ***Wheat and barley (green crops)***

Because data of the yields of green crop wheat and barley (excluding those for fodder) were not directly available, the annual yields were calculated by multiplying the area planted with wheat for green crops and other purposes, as shown in the *Statistics of Cultivated and Planted Area*, by the yield per unit area established for green crop rye and oats (excluding those for fodder) and proportionally divided by the yield of wheat and barley (grain).

- ***Rye and oats***

Because data of the yields of rye and oats were not directly available, the total annual yields were calculated by multiplying the area planted with rye or oats, as indicated based on the *Statistics of Cultivated and Planted Area*, by the yield per unit area.

Table 6-62 Yield of rye and oats per unit area

Crop	Yield per unit area [kg/10a]	Data Source
Rye (grain)	424	Determined by specialists (based on rye crop tests in Japan)
Oats (grain)	223	MAFF, *Crop Statistics* (Reference 14)
Rye and Oats (green crops)	1,100	Determined by specialists (based on literature)

- ***Residue/ Crop production ratio, dry matter fraction in residue, carbon content, proportion burned in field, and oxidation rate.***

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 surveyed by MAFF as shown in Table 6-60. Since the survey data don’t exist for before FY2006, the value for FY2007 is applied to these years. Table 6-61 shows other parameters for each crop.

Table 6-63 Proportion burned in field for wheat, barley, rye and oats

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012	2013
Proportion burned in field	%	13.5	13.5	13.5	13.5	12.5	11.6	10.6	9.5	9.2	9.2

*Estimated from the survey by MAFF

- ***Nitrogen content***

The specific nitrogen content value was determined for each of rice, wheat, barley, and oats (green crop), based on the results of various studies carried out in Japan. The nitrogen content of green crop wheat/barley was calculated using the average of nitrogen contents in wheat and barley weighted by yield. The default nitrogen content values in the *GPG (2000)* were used for rye and oats (grain). The nitrogen content for rye (green crop) was calculated by multiplying Japan’s country-specific value for oats (green crop) by the value resulting from “rye (grain) / oats (grain)”.

Table 6-64 Proportions of residue to crop yield, dry matter in residue, carbon content, and oxidation rate

Crop	Residue/ Crop product ratio	Dry matter fraction in residue a)	Carbon content	Nitrogen content	Oxidation rate
Rice (straw)	---	0.85 [a]	0.4144 [a]	0.0054 [j]	0.90 [b]
Rice (chaff)	---	0.85 [a]	0.4144 [a]	0.0042 [j]	
Wheat (grain)	1.39 [i]	0.85 [a]	0.4853 [a]	0.00368 [i]	
Barley (grain)	1.39 [i]	0.85 [a]	0.4567 [a]	0.00368 [i]	
Wheat/barley (green crop)	---	0.17 [c]	0.48 [d,g]	0.017 [h,g]	
Rye	2.84 [e]	0.90 [c]	0.4710 [f]	0.0048 [f]	
Oats	2.23 [e]	0.92 [c]	0.4710 [f]	0.007 [f]	
Rye (green crop)	---	0.17 [c]	0.4710 [f]	0.0116 [h]	
Oats (green crop)	---	0.17 [c]	0.4710 [f]	0.0169 [h]	

a: *GPG (2000)*, p. 4.58, Table 4.16 (Reference 4)

b: Survey by MAFF

c: Determined based on the percentage of dry matter in green crop wheat indicated in the *Standard Table of Feed Composition in Japan* (National Agriculture Research Organization, pub. by Japan Livestock Association)

d: Determined based on the values shown in the *GPG (2000)* for wheat (grain) and barley (grain) by apportioning for yields

e: Determined based on the results of crop tests for rye and oats in Japan

f: Used the average of the values shown for “wheat” and “barley” in the *Good Practice Guidance (2000).*

g: Values change over the years

h: Owa N., *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 33)

i: Matsumoto N., Development of Estimation Method and Evaluation of Nitrogen Flow in Regional Areas (2000) (Reference 55)

j: Date N., *“Handbook for Organic Fertilizers and Microbial Materials”*, (1988) (Reference 59)

c） Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment was conducted by each crop. The uncertainties for emission factors were calculated to combine the uncertainty of each parameter determined by expert judgment or given in the *GPG (2000)* as the default values. The uncertainties for activity data applied the standard error in each statistics (the *Crop Statistics* and the *Statistics of Cultivated and Planted Area*) or the value decided by the 2002 Committee for Greenhouse Gas Emission Estimation Methods. The uncertainty assessment results of the emissions by each crop were provided in Annex 7 Table 11. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d） Source-specific QA/QC and Verification

Tier 1 QC activities have been conducted in accordance with the *GPG (2000)* methods. Tier 1 QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials.

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）Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions from FY 2010 to FY2011 were revised in accordance with the revision and/or update of the activity data from FY2011 to FY2012.

f）Source-specific Planned Improvements

For the use of the default parameter in the *Revised 1996 IPCC Guidelines* or the *GPG (2000)*,it is needed to discuss whether country-specific parameter can be established for Japan.

6.7.2. Maize, Peas, Soybeans, Adzuki beans, Kidney beans, Peanuts, Potatoes, Sugarbeets & Sugar cane (4.F.1., 4.F.2., 4.F.3., 4.F.4.)

a）Source/Sink Category Description

This section provides the estimation methods for CH_4 and N_2O emissions from field burning of agricultural residues by maize, peas, soybeans, adzuki beans, kidney beans, peanuts, potatoes, sugarbeet and sugar cane.

b）Methodological Issues

● ***Estimation Method***

CH_4 and N_2O emissions were calculated in accordance with the relevant decision tree in the *GPG (2000)* (page 4.52, Fig. 4.6), by multiplying the total carbon released or total nitrogen released, as calculated by the default method, by the emission factors.

● ***Emission Factors***

Same emission factors used for rice, wheat, and barley residues were used (Table 6-60)

● ***Activity Data***

Activity data was calculated by multiplying the yield of each crop shown in the *Crop Statistics* and the *Vegetable Production and Shipment Statistics* published by MAFF by the parameters shown in the following calculation formula.

Total carbon released by field burning of agricultural residues [kg-C] (potatoes, sugarbeets, sugarcane)
= Annual crop production [t] × Residue/Crop product ratio × Dry matter fraction in residue [t-dm/t] × Proportion burned in field × Oxidation rate × Carbon content of residues [t-C/t-dm] × 10^3

Total carbon released by field burning of agricultural residues [kg-C] (crops other than potatoes, sugarbeets, sugarcane)
= Annual crop production [t] × Residue/Crop product ratio [t-dm/t] × Proportion burned in field × Oxidation rate × Carbon content of residues [t-C/t-dm] × 10^3

Total nitrogen released by field burning of agricultural residues [kg-N]
= Annual crop production [t] × Residue/Crop product ratio × Proportion burned in field × Oxidation rate × Carbon/nitrogen content of residues [t-N/t-dm or t-N/t] × 10^3

Table 6-65 Residue/ crop product ration, dry matter, carbon content, nitrogen content, proportion burned in field , and oxidation rate

Crop	Residue/ Crop product ratio	Dry matter fraction in residue	Carbon content	Nitrogen content	Proportion burned in field	Oxidation rate
Maize	1.20 [e A]	0.86 [h]	0.4709 [h D]	0.0035 [e E]	0.10[c]	0.90[c]
Peas	0.60 [e A]	0.87 [h]	0.45 [a D]	0.0101 [e E]		
Soybean	1.40 [e A]	0.89 [h]	0.45 [a D]	0.0109 [e E]		
Adzuki beans	0.89 [e A]	0.89 [h]	0.45 [a D]	0.0098 [e E]		
Kidney beans	0.60 [e A]	0.89 [h]	0.45 [a D]	0.0101 [e E]		
Peanuts	0.94 [e A]	0.86 [h]	0.45 [a D]	0.0054 [e E]		
Potatoes	0.032 [b B]	-	0.4226 [h D]	0.0222 [f D]		
Sugarbeets	0.062 [b B]	-	0.4072 [h D]	0.0154 [f D]		
Sugar cane	0.102 [g B]	-	0.4235 [h D]	0.0055 [g D]		

A: Residue (wet) / Crop production (wet)

B: Residue (dry) / Crop production (wet)

D: N content (or C content) / Residue (dry)

E: N content (or C content) / Residue (wet)

Source:

a. In the absence of default values, the values for dicotyledonous and monocotyledonous plants were used. Murayama, N., et al.., *Alimentation of Crops and Fertilizer*, Buneido, p. 26 (Bowen: Trace Elements in Biochemistry, 1966)

b. Owa, *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 33)

c: *Revised 1996 IPCC Guidelines*

d: Although default values are not available, the median value of the values indicated in the *Revised 1996 IPCC Guidelines*, Vol. 2, p. 4.30 (0.001 – 0.02) were used.

e: Matsumoto N., Development of Estimation Method and Evaluation of Nitrogen Flow in Regional Areas (2000) (Reference 55)

f: Hokkaido Government, Hokkaido Fertiliser Recommendations 2010. (2010) (Reference 56)

g: Document of Kagoshima prefectural Institute for Agricultural Development

h: *GPG (2000)*, p. 4.58, Table 4.16 (Reference 4)

c) Uncertainties and Time-series Consistency

- ***Uncertainties***

The uncertainty assessment was conducted by each crop. The uncertainties for emission factors were calculated to aggregate the uncertainty of each parameter determined by expert judgment and given for default values in *the GPG (2000)*. For the uncertainties of the activity data, the value decided by the Committee for Greenhouse Gas Emission Estimation Methods in 2002 was applied. The uncertainty assessment results of the emissions by each crops were provided in Annex 7 Table 11. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series Consistency***

Emissions are estimated by using consistent estimation methods and data sources.

d) Source-specific QA/QC and Verification

Refer to section" 6.7.1. rice, wheat, barley, rye, and oats".

e) Source-specific Recalculations

In the agriculture sector, a 3-year average has been used. Thus, the emissions for FY2011 were revised in accordance with the revision and/or update of the activity data for FY2012.

f) Source-specific Planned Improvements

For the use of the default parameter in the *Revised 1996 IPCC Guidelines* or the *GPG (2000)*, it is needed to discuss whether country-specific parameter can be established for Japan.

6.7.3. Dry bean (4.F.2.-)

Dry beans are a type of kidney beans, and the term refers to the mature, husked vegetable. Kidney beans in Japan are eaten before ripening, however, which means there is little of this type of product. Kidney beans are included in beans (4.F.2.), under 'other crops' and, therefore, the dry beans have been reported as "IE".

6.7.4. Other (4.F.5.)

It is possible that agricultural residue other than cereals, pulse, root vegetables and sugar canes are burnt in the fields. However, data on actual activity is not available and it is not possible to establish the emission factor. Therefore, these sources have been reported as "NE".

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Chapter 7. Land Use, Land-Use Change and Forestry (CRF sector 5)

7.1. 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 *GPG-LULUCF*. It also uses 20 years, a default value in the *GPG-LULUCF*, 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), direct N_2O emissions from N fertilization, N_2O emissions from drainage of soils, N_2O emissions from disturbance associated with land-use conversion to cropland, CO_2 emissions from agricultural lime application, and non-CO_2 emissions from biomass burning. 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 FY2012 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 25.0 million ha. The second-largest portion is cropland, which covers about 3.94 million ha. In addition, grassland, wetlands, settlements, and other land cover about 0.95 million ha, 1.34 million ha, 3.78 million ha, and 2.83 million ha, respectively.

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]

The LULUCF sector contains both sources and sinks; however, in Japan, it has been a net sink continuously since FY1990. Net removals in FY2012 were 75,065 Gg-CO_2; this accounts for 5.6% of the total national emissions (excluding LULUCF). The net removals in FY2012 also represent an increase of 12.3% over the FY1990 value and a decrease of 0.7% below the FY2010 value. The key drivers for the rise in removals since 1990 are increase of removals in forest land and decrease of

[1] Statistical reports on the land area by prefectures and municipalities in Japan <http://www.gsi.go.jp/KOKUJYOHO/MENCHO-title.htm>

[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 Northernmost, Southernmost, Easternmost and Westernmost Points* <http://www.gsi.go.jp/KOKUJYOHO/center.htm>.

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 14 sections. Section 7.2 describes the method of determining land-use categories. Section 7.3 describes general parameters for estimating carbon stock changes from land-use conversion. Sections 7.4 to 7.9 explain the estimation methods of carbon stock changes in each land-use category. GHG emissions by the LULUCF sector resulting from other than carbon stock changes are described in sections 7.10 to 7.14.

7.2. Method of determining land-use categories

7.2.1. Basic approach

In accordance with the 6 land-use categories in the *GPG-LULUCF*, land is classified on the basis of the definitions in existing statistics and other sources. As for forest land and cropland, 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).

“Land remaining Land” and “Land converted to Land” in each land-use category are determined based on existing statistics. 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.

Table 7-1 Land-use transition matrix for Japan in FY1990

(kha)

After Conversion \ Before Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest Land	24,946.7	2.7	0.7	NO	0.1	0.1	24,950.3
Cropland	7.3	4,587.8	0.002	0.3	IE	0.9	4,596.4
Grassland	1.0	0.9	1,017.6	0.1	NO	1.9	1,021.6
Wetlands	0.3	0.02	0.01	1,318.0	0.002	0.1	1,318.4
Settlements	20.2	21.4	3.2	IE	3,174.2	IE	3,219.0
Other land	5.0	15.4	3.9	IE	IE	2,643.8	2,668.1
Total	24,980.6	4,628.2	1,025.3	1,318.5	3,174.3	2,646.9	37,773.7

Table 7-2 Land-use transition matrix for Japan in FY2012

(kha)

After Conversion \ Before Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest Land	24,959.4	0.1	0.0	0.0	0.0	0.02	24,959.5
Cropland	0.5	3,930.6	0.001	0	IE	4.6	3,935.7
Grassland	0.1	0.4	952.4	0	NO	0.4	953.3
Wetlands	0.1	0.01	0.003	1,338.4	0.001	0.0	1,338.6
Settlements	4.5	6.4	1.1	IE	3,766.0	IE	3,778.0
Other land	0.3	7.7	1.8	IE	IE	2,821.1	2,831.0
Total	24,964.9	3,945.1	955.3	1,338.4	3,766.1	2,826.2	37,796.0

Table 7-3 Land-use transition matrix for FY1990-FY2012

(kha)

2012 \ 1990	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest Land	24,926.0	23.9	5.4	0.0	2.5	1.76	24,959.5
Cropland	32.6	3,862.5	0.476	1	IE	39.1	3,935.7
Grassland	4.9	20.7	910.3	0	NO	17.1	953.3
Wetlands	14.2	1.06	0.367	1,318.9	0.070	3.9	1,338.6
Settlements	225.1	327.7	49.6	IE	3,175.6	IE	3,778.0
Other land	66.4	337.6	86.1	IE	IE	2,340.9	2,831.0
Total	25,269.1	4,573.3	1,052.2	1,320.4	3,178.2	2,402.7	37,796.0

(Note) The conversion areas indicated as "IE" are included in "other land remaining other land" which contains implication of an adjustment item of the national total land.

7.2.2. Methods of determining land-use categories and areas

Japan determines land-use categories and areas on the basis of existing statistics (Table 7-4). 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 11.3.2.3 in Chapter 11.

Table 7-4 Method of determining land use categories and areas

Land use category	Method of determining land use category	Method of determining 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] Definitions of forest subcategories are given in Table 7-5.
Cropland	Rice fields, upland fields and orchard.	Rice fields, upland fields and orchard according to *Statistics of Cultivated and Planted Area* by the MAFF.
Grassland	Pasture land, grazed meadow land (excluding when it is included in forest land) and grassland other than pasture land and grazed meadow land[4].	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 grassland other than pasture land and grazed meadow land identified in *Land Use Status Survey* by the MLITT.
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 MLITT. 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 MLITT. The included figures for urban green areas are taken from the surveys on urban green facilities conducted by the MLITT. (Details are shown in Table 11-10).
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; MLITT: Ministry of Land, Infrastructure, Transport and Tourism

Table 7-5 Definitions of forest subcategories

<u>Forest with standing trees:</u> 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.	<u>Intensively managed forest:</u> 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. <u>Semi-natural forest:</u> Forest with standing trees which is not classified as intensively managed forests
<u>Forest with less standing trees:</u> Forest in which the sum of the tree crown covers of both standing trees and bamboo is less than 30 percent.	
<u>Bamboo:</u> Forest that does not fall under "forest with standing trees" and has a tree crown cover of bamboo (excluding "sasa" (a genus of running bamboo)) 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, while dominated by bamboo is also included.	

Reference: Forestry Agency of Japan, *Forest Status Survey* (March, 2007) *partially modified

[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] Grassland other than pasture land and grazed meadow land is the land that remains after subtracting grazed meadow land and national land under the jurisdiction of the Forestry Agency from grassland other than forests in the *World Census of Agriculture and Forestry*. 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.

7.2.3. Survey methods and due dates of major land area statistics

Table 7-6 shows the survey methods and due dates of major land area statistics.

Table 7-6 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) [Expansion area and converted area of cropland] Tabular survey (using documents from relevant agencies and aerial photographs, etc.)	[Cropland area] July, 15th [Expansion area and converted area of cropland] July, 15th in the previous year until July, 14th	Every year	MAFF
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	MLITT
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 11-10.

MAFF: Ministry of Agriculture, Forestry and Fisheries; MLITT: Ministry of Land, Infrastructure, Transport and Tourism

7.2.4. Land area estimation methods

Some land areas cannot be directly determined from existing statistics; therefore, they are estimated using the following methods:

- Interpolation or trend extrapolation
- 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 and trend extrapolation***

➢ ***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 or extrapolation by means of linear expressions based on the areas in the surveyed years.

➢ ***Land-use category***

5.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***

5.A.2. Land (Cropland and Grassland) converted to Forest land
5.B.2. Land (Forest land, Grassland, Wetlands and Other land) converted to Cropland
5.C.2. Land (Forest land, Cropland, Wetlands and Other land) converted to Grassland
5.E.2. Land (Cropland and Grassland) converted to Settlements
5.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***

5.D.2. Land (Cropland, Grassland, Settlements and Other land) converted to Wetlands

7.3. 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 (Tables 7-7a to 7-10) to prevent the reiteration of indicating these parameters in each subsequent section. For some parameters and estimation methods, details are given in the section indicated in "Note".

Table 7-7a 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		122.0 [t-d.m./ha] (FY2012)	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 2004 are extrapolated by means of trend from 2005 to the latest year. (Reference values [t-d.m./ha]: FY1990: 112.3, FY2005: 112.3, FY2008: 133.7, FY2009: 107.3, FY2010: 98.8, FY2011: 99.6)
	Cropland	Rice field	0	Biomass stocks are assumed to be "0".
		Upland field	0	Biomass stocks are assumed to be "0".
		Orchard	30.63 [t-C/ha]	Calculated by multiplying the average age and growth rate given in Ito *et al.* "*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*"
	Grassland		13.50 [t-d.m./ha]	*GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet)
	Wetlands, settlements and other land		0	Biomass stocks are assumed to be "0".
Immediately after conversion	All land uses		0	Biomass stocks immediately after conversion are assumed to be "0".

Table 7-7b Living biomass growth increments for each land-use category after conversion

Land use category			Biomass growth increment	Note
After conversion	Forest land		-	Removals in this land are directly estimated based on the implied removal factor of AR activity under the Kyoto Protocol. See section 7.4.2.b)1)
	Cropland	Rice field	0	Biomass stocks are assumed to be "0".
		Upland field	0	Biomass stocks are assumed to be "0".
		Orchard	0	Biomass stocks are assumed to be "0".
	Grassland		2.70 [t-d.m./ha/yr]	One fifth of the value of *GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet)
	Settlements		-	See section 7.8.2.b)1)
	Wetlands and other land		0	Biomass stocks are assumed to be "0".

Table 7-8 Carbon stocks of dead wood for each land-use category before and after conversion

Land-use Category		Carbon Stock	Note
Before Conversion	Forest land	14.93 [t-C/ha] (FY2012)	Calculated from carbon stocks in dead wood in all forests. (Reference values [t-C/ha]: FY1990: 15.08, FY2005: 15.08, FY2008: 15.02, FY2009: 14.99, FY2010: 14.97, FY2011: 14.95)
	Cropland, grassland, wetlands, settlements, other land	0*	Assumed as zero (Section 4.3.2 in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
Immediately after conversion	All land uses	0	Biomass 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*	Assumed as zero (Section 4.3.2 in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
	Settlements	0	Assumed as zero

* For some subcategories, stock changes are estimated as zero despite the fact that carbon stock values exist. See each section for details.

Table 7-9 Carbon stocks of litter for each land-use category before and after conversion

Land-use Category		Carbon Stock [t-C/ha]	Note
Before Conversion	Forest land	7.29 [t-C/ha] (FY2012)	Calculated from carbon stocks in litter in all forests. (Reference values [t-C/ha]: FY1990: 7.24, FY2005: 7.24, FY2008: 7.26, FY2009: 7.27, FY2010: 7.28, FY2011: 7.28)
	Cropland, grassland, wetlands, settlements, other land	0*	Assumed as zero (Section 4.3.2 in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
Immediately after conversion	All land-uses	0	Biomass 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*	Assumed as zero (Section 4.3.2 in Volume 4 of the 2006 IPCC Guidelines, Tier.1)
	Settlements	—	See section 7.8.2.b)2)

* For some subcategories, stock changes are estimated as zero despite the fact that carbon stock values exist. See each section for detail.

Table 7-10 Carbon stocks of soil for each land-use category before and after conversion

Land-use Category		Carbon Stock	Note
Before conversion	Forest land	85.30 [t-C/ha] (FY2012)	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 FY2006 is applied to the years before 2005. (Reference values [t-C/ha]: FY1990: 85.07, FY2005: 85.07, FY2008: 85.14, FY2009: 85.12, FY2010: 85.17, FY2011: 85.20)
	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) cropland: see section 7.5.2.b)3) grassland (pasture land): see section 7.6.2.b)2) * These carbon stocks were not applied to cropland converted to grassland.
	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 (*GPG-LULUCF* Table 3.3.3, 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.
	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) cropland: see section 7.5.2.b)3) grassland (pasture land): see section 7.6.2.b)2)
	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	-	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 80tC/ha due to expert judgment.

7.4. Forest land (5.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 FY2012 was about 25.0 million ha—about 66.0% of the total national land area. The net removal by this category in FY2011 was 77,673 Gg-CO_2 (excluding 1.75 Gg-CO_2 eq. of CH_4 and N_2O emissions resulting from biomass burning and 0.55Gg-CO_2 eq. of N_2O emission resulting from N fertilization). This represents a decrease of 1.1% below the FY1990 value, and a decrease of 0.3% below the FY2012 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 (5.A.1.)" and "Land converted to Forest land (5.A.2.)", and they are described separately in the following subsections.

Table 7-11 Emissions and removals in forest land resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.A. Forest land	Total	Gg-CO_2	-78,562.7	-87,329.7	-90,663.9	-92,469.2	-80,334.7	-75,674.8	-75,942.2	-77,917.6	-77,672.7
		Living Biomass	Gg-CO_2	-72,503.2	-79,549.5	-83,686.6	-87,358.7	-76,900.2	-72,911.4	-73,815.3	-76,348.4	-76,538.3
		Dead Wood	Gg-CO_2	-2,860.4	-3,803.1	-2,836.6	-1,082.1	194.6	688.9	1,163.2	1,566.7	1,857.9
		Litter	Gg-CO_2	-2,696.6	-2,352.5	-1,773.9	-1,078.0	-742.1	-620.6	-525.2	-456.7	-410.1
		Mineral soil	Gg-CO_2	-502.5	-1,624.6	-2,366.8	-2,950.3	-2,887.1	-2,831.8	-2,764.9	-2,679.2	-2,582.3
		Organic soil	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
	5.A.1. Forest land remaining Forest land	Total	Gg-CO_2	-76,556.2	-86,329.2	-89,948.6	-91,927.8	-79,847.1	-75,236.4	-75,533.0	-77,541.2	-77,324.2
		Living Biomass	Gg-CO_2	-71,074.1	-78,835.1	-83,176.8	-86,971.8	-76,553.2	-72,598.4	-73,522.6	-76,077.7	-76,286.8
		Dead Wood	Gg-CO_2	-2,511.9	-3,630.5	-2,712.6	-989.0	279.6	764.7	1,233.5	1,630.5	1,916.5
		Litter	Gg-CO_2	-2,545.5	-2,277.7	-1,720.1	-1,037.6	-705.3	-587.7	-494.7	-429.0	-384.7
		Mineral soil	Gg-CO_2	-424.6	-1,586.0	-2,339.1	-2,929.5	-2,868.1	-2,814.9	-2,749.2	-2,664.9	-2,569.2
		Organic soil	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO
	5.A.2. Land converted to Forest land	Total	Gg-CO_2	-2,006.5	-1,000.5	-715.3	-541.3	-487.7	-438.5	-409.2	-376.4	-348.6
		Living Biomass	Gg-CO_2	-1,429.0	-714.4	-509.8	-387.0	-346.9	-312.9	-292.7	-270.6	-251.5
		Dead Wood	Gg-CO_2	-348.5	-172.7	-124.0	-93.2	-84.9	-75.8	-70.3	-63.9	-58.6
		Litter	Gg-CO_2	-151.0	-74.8	-53.7	-40.4	-36.8	-32.8	-30.5	-27.7	-25.4
		Mineral soil	Gg-CO_2	-77.9	-38.6	-27.7	-20.8	-19.0	-16.9	-15.7	-14.3	-13.1
		Organic soil	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO

7.4.1. Forest land remaining Forest land (5.A.1.)

a） *Source/Sink 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 FY2012. The net removal by this subcategory in FY2012 was 77,324 Gg-CO_2 (excluding 1.75 Gg-CO_2 eq. of CH_4 and N_2O emissions resulting from biomass burning and 0.55 Gg-CO_2 eq. of N_2O emission resulting from N fertilization). This represents an increase of 1.0% over the FY1990 value and a decrease of 0.3% below the FY2011 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. 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 thereafter net emissions. 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 afforested in 1960s were 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 *GPG-LULUCF*, carbon stock changes in living biomass in all forest land are estimated by the Tier 2 stock change 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].

$$\Delta C_{LB} = \sum_k \{(C_{t2} - C_{t1})/(t_2 - t_1)\}_k$$

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.

$$C = \sum_j \{[V_j \cdot D_j \cdot BEF_j] \cdot (1 + R_j) \cdot CF\}$$

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 method of estimating carbon stock change in land converted to forest land, see section 7.4.2.b)1).

[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.

- ***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 7-12 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 7-12 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).

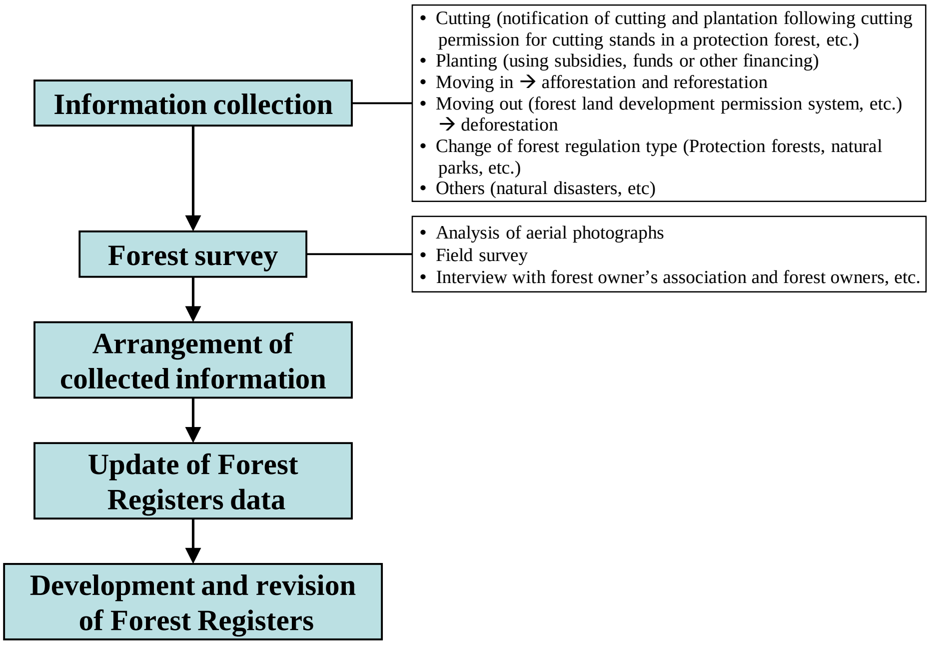

Figure 7-1 Procedures for developing Forest Registers

- ***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 7-13).

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 7-13). These D values were established only for tree species, because wood density was not correlated with forest age.

➢ *Carbon fraction of dry matter*

The default value given in the *GPG-LULUCF* has been adopted as the carbon fraction (CF) of dry matter (Table 7-13).

Table 7-13 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./m³]	[t-C./t-d.m]	
Conifer trees	Japanese cedar	1.57	1.23	0.25	0.314	0.5	
	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		
	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 7-14 Classifications in Forest Status Survey (before 2004) and National Forest Resource Database (after 2005)

<table>
<tr><th colspan="2">Conifer trees</th><th colspan="2">Broad leaf trees</th></tr>
<tr><th>Before 2004</th><th>After 2005</th><th>Before 2004</th><th>After 2005</th></tr>
<tr><td>Japanese cedar</td><td>Japanese cedar</td><td>Japanese chestnut oak</td><td>Japanese chestnut oak</td></tr>
<tr><td>Hinoki cypress</td><td>Hinoki cypress</td><td>Oak (deciduous tree)</td><td>Oak (deciduous tree)</td></tr>
<tr><td rowspan="2">Pine</td><td>Japanese red pine</td><td rowspan="17">Other broad leaf</td><td>Japanese beech</td></tr>
<tr><td>Japanese black pine</td><td>Oak (evergreen tree)</td></tr>
<tr><td>Japanese larch</td><td>Japanese larch</td><td>Japanese chestnut</td></tr>
<tr><td>Sakhalin fir</td><td>Sakhalin fir</td><td>Japanese poplar</td></tr>
<tr><td rowspan="2">Yezo spruce</td><td>Yezo spruce</td><td>Alder</td></tr>
<tr><td>Sakhalin spruce</td><td>Japanese elm</td></tr>
<tr><td rowspan="9">Other conifer</td><td>Sawara cypress</td><td>Japanese zelkova</td></tr>
<tr><td>Hiba arborvitae</td><td>Cercidiphyllum</td></tr>
<tr><td>Momi fir</td><td>Japanese big-leaf magnolia</td></tr>
<tr><td>Japanese hemlock</td><td>Maple tree</td></tr>
<tr><td>Japanese umbrella pine</td><td>Amur cork</td></tr>
<tr><td>Japanese yew</td><td>Japanese lime</td></tr>
<tr><td>Ginkgo</td><td>Linden</td></tr>
<tr><td>Exotic conifer trees</td><td>Kalopanax</td></tr>
<tr><td>Other needle leaf</td><td>Paulownia</td></tr>
<tr><td colspan="2" rowspan="2"></td><td>Exotic broad leaf trees</td></tr>
<tr><td>Other broad leaf</td></tr>
</table>

➢ ***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 7.4.2.b)1).

Table 7-15 Area of forest land remaining forest land within the past 20 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Forest land remaining Forest land		kha	24,804.1	24,824.5	24,824.0	24,953.1	24,933.5	24,916.1	24,936.7	24,941.3	24,934.9
	Intensively managed forests	kha	10,141.7	10,283.2	10,278.5	10,297.4	10,272.8	10,266.7	10,255.6	10,253.8	10,247.2
	Semi-natural forests	kha	13,354.5	13,220.3	13,195.2	13,315.7	13,333.5	13,349.6	13,360.8	13,359.5	13,355.2
	Cut-over forests and lesser stocked forests	kha	1,159.0	1,171.0	1,197.4	1,186.0	1,170.8	1,142.8	1,161.7	1,169.0	1,170.8
	Bamboo	kha	149.0	150.0	152.9	154.0	156.4	157.1	158.6	159.1	161.7

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 *GPG-LULUCF*, 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

Soil drainage in forest land with organic soils is not implemented in Japan in accordance with expert judgment. Under this circumstance, CO_2 emissions from organic soils in forest land do not occur and were 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 7-16). 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*. (in preparation).

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 7-16). 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.

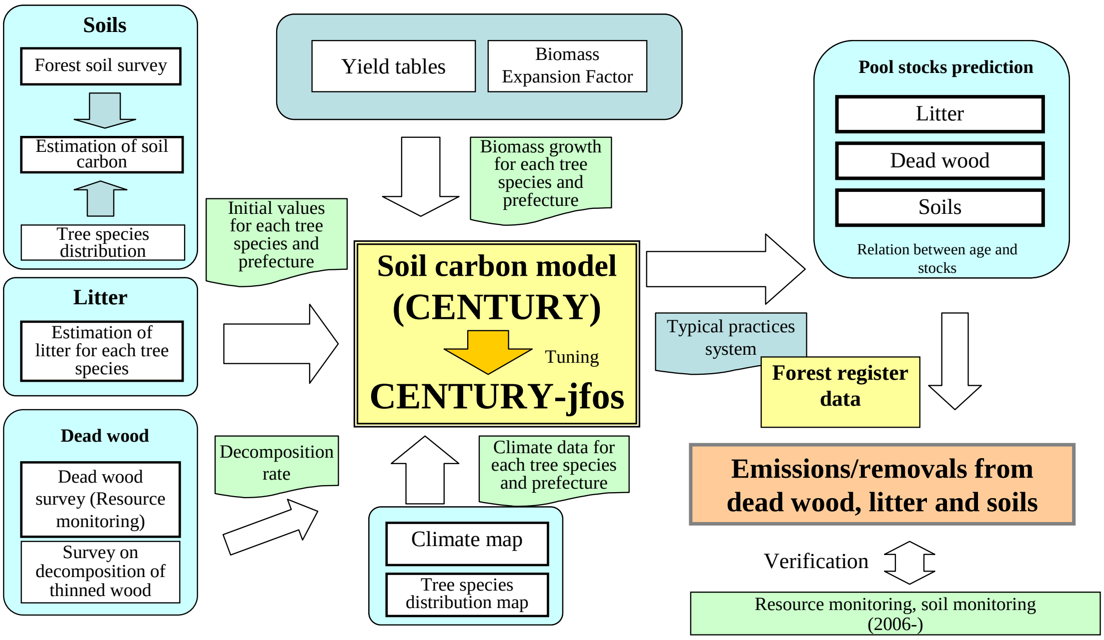

Figure 7-2 Estimation of emissions/removals in dead wood, litter and soils

Table 7-16 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 *GPG-LULUCF*. 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 11% for the total removals by forest land remaining forest land. The methodology used in the uncertainty assessment was in accordance with the guideline described in Annex 7. Uncertainty estimates regarding the major parameters in this category are shown in Table 7-17.

Table 7-17 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		2.0	D	Estimated based on the *GPG-LULUCF* default value. Used 2.0% without distinguishing tree species.
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） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

- ***Areas of intensively managed forests***

Areas of intensively managed forests in forest land remaining forest land are estimated by subtracting areas of land converted to forest land from those of whole intensively managed forests. Areas of the intensively managed forests in forest land remaining forest land were recalculated because areas of afforestation and reforestation (AR areas) were revised. As a result of recalculation of the areas, carbon stock changes in living biomass, dead organic matter and mineral soils in intensively managed forests in forest land remaining forest land were also recalculated. For detailed information on the revision of the estimation method for the areas of afforestation and reforestation, see “*Revisions of AR and D areas and recalculation of FM areas*” in section 11.4.1.4. in chapter 11 in this NIR.

- ***Correction to removals/emissions by forest land remaining forest land in accordance with revision of Forest Registers' data***

When Forest Registers' data such as tree species and areas were revised in updates of the Register in order to make them reflect correct status of forests, correction to removals/emissions by forest land remaining forest land was implemented to obtain appropriate values, because, under the stock change method, it would regard the difference between carbon stock without revision at a point of time and that with revision at another point of time as the carbon stock change between the two points of time. Concretely speaking, the Forest Registers' data were comprehensively revised by reviewing data by 2006 in which estimation of emissions and removals by the stock change method was started. As a result, emissions and removals from 2008 to 2011 in forest land remaining forest land were recalculated.

- ***Area of organic soils in forest land***

Areas of organic soils in forest land were reported as “IE” up until the previous submission because the areas were included in those areas with mineral soils in forest land. From this submission, the areas of organic soils were reported separately by applying ratios of organic soil areas to semi-natural forests because areas of organic soils in forest land exist only in semi-natural forests in Japan. Hence, the areas of organic soil were reported only in semi-natural forests, and were reported as “NO” in intensively managed forests, in bamboo and in forests with less standing trees.

f） ***Source-/Sink-specific Planned Improvements***

None.

7.4.2. Land converted to Forest land (5.A.2)

a） ***Source/Sink 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 FY2012 was 348.59 Gg-CO_2. This represents a decrease of 82.6% below the FY1990 value and a decrease of 7.4% below the FY2011 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 FY2005 and FY2008 (2.8 t-C/ha) was applied to all reporting years.

➢ ***Biomass stock in each Land-Use Category***

The parameters of orchard and grassland before conversion, shown in Table 7-7a, are 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 7-4. 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 6 of chapter 5 in the *GPG-LULUCF*, 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 FY2006 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 FY2006 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 11.3.2.3 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. For further information on determining AR areas, see section 11.3.2.3 in Chapter 11.

➢ ***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. For further information on determining AR areas, see section 11.3.2.3 in Chapter 11.

Table 7-18 Area of land converted to forest land (single year)

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Forest land	kha	3.54	1.60	1.42	0.78	2.22	1.20	1.26	0.37	0.10
Cropland converted to Forest land	kha	2.71	1.22	1.08	0.57	1.10	0.73	0.61	0.23	0.05
Rice field	kha	0.92	0.47	0.41	0.17	0.36	0.24	0.21	0.06	0.01
Upland field	kha	1.31	0.57	0.51	0.31	0.58	0.39	0.32	0.13	0.03
Orchard	kha	0.49	0.19	0.15	0.09	0.16	0.10	0.08	0.03	0.01
Grassland converted to Forest land	kha	0.67	0.31	0.28	0.17	0.04	0.06	0.02	0.02	0.002
Wetlands converted to Forest land	kha	NO	NO	NO	NO	0.0025	0.0023	0.0014	0.0007	0.0001
Settlements converted to Forest land	kha	0.08	0.04	0.03	0.02	0.68	0.28	0.39	0.09	0.03
Other land converted to Forest land	kha	0.08	0.04	0.03	0.02	0.40	0.13	0.24	0.04	0.02

Table 7-19 Land converted to forest land within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Forest land	kha	146.1	72.4	52.0	39.1	35.6	31.8	29.5	26.8	24.6
Cropland converted to Forest land	kha	121.9	57.7	40.6	30.0	26.0	23.0	20.9	18.7	17.0
Rice field	kha	53.8	23.7	15.9	11.0	9.2	8.6	7.8	7.1	6.4
Upland field	kha	46.8	23.7	17.7	14.0	12.6	10.9	9.9	8.9	8.2
Orchard	kha	21.4	10.3	6.9	4.9	4.2	3.5	3.1	2.7	2.5
Grassland converted to Forest land	kha	19.3	11.6	9.0	7.3	6.3	5.3	4.7	4.1	3.7
Wetlands converted to Forest land	kha	NO	NO	NO	NO	0.0	0.0	0.0	0.0	0.0
Settlements converted to Forest land	kha	2.4	1.6	1.2	0.9	1.8	2.0	2.3	2.3	2.3
Other land converted to Forest land	kha	2.4	1.6	1.2	0.9	1.5	1.5	1.6	1.6	1.6

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 7-8 (dead wood), Table 7-9 (litter) and Table 7-10 (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 7-19.

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 *GPG-LULUCF*. As a result, the uncertainty estimate was 38% for the entire removal by land converted to forest land. The methodology used in the uncertainty assessment is described in Annex 7.

- ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

d) ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e) ***Source-/Sink-specific Recalculations***

- ***Areas of wetlands, settlements and other land converted to forest land***

Areas of wetland, settlements and other land converted to forest land from FY1990 to FY2005, which had been reported collectively in the areas of other land converted to forest land, were reported by disaggregating them into each subcategory. Accordingly, carbon stock changes in living biomass, dead organic matter and soil in these subcategories were recalculated.

- ***Areas of land converted to forest land***

Breakdown of areas of forest land converted from other land-use categories since FY2007 was revised as a result of revision of ratios of afforestation, reforestation and deforestation (ARD ratios). Accordingly, carbon stock changes in living biomass, dead organic matter and mineral soils in this category were recalculated. For detailed information on the revision of the estimation method for the areas of afforestation and reforestation, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

● ***Carbon stock changes in living biomass in cropland converted to forest land***

Carbon stock changes in living biomass in orchard converted to forest land were recalculated because of revision of the incorrect unit of a parameter on biomass stock in orchard before conversion

f) ***Source-/Sink-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.

7.5. Cropland (5.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 and orchards.

In FY2012, Japan's cropland area was about 3.94 million ha, which is equivalent to about 10.4% of the national land. The area of organic soil in cropland is about 0.18 million ha. The emissions from this category in FY2012 were 1,641 Gg-CO_2 (excluding 4.0 Gg-CO_2 eq. of N_2O emissions resulting from disturbance associated with land-use conversion to cropland and 247 Gg-CO_2 of CO_2 emissions resulting from lime application to agricultural soils); this represents a decrease of 60.8% below the FY1990 value and a decrease of 4.0% below the FY2011 value.

This section divides cropland into two subcategories, "Cropland remaining Cropland (5.B.1.)" and "Land converted to Cropland (5.B.2.)", and describes them separately in the following subsections.

Table 7-20 Emissions and removals in cropland resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.B. Cropland	Total	Gg-CO_2	4,188.2	2,322.1	1,867.2	1,754.4	1,715.8	1,861.1	1,757.8	1,709.1	1,641.2
		Living Biomass	Gg-CO_2	1,507.5	307.6	98.8	118.5	129.1	235.9	169.0	146.4	112.1
		Dead Wood	Gg-CO_2	405.0	82.5	26.5	31.6	29.1	66.1	51.3	44.0	27.5
		Litter	Gg-CO_2	194.5	39.6	12.7	15.2	14.0	31.9	24.9	21.4	13.4
		Mineral soil	Gg-CO_2	548.9	403.5	265.7	157.9	128.4	116.8	106.2	100.6	94.1
		Organic soil	Gg-CO_2	1,532.3	1,489.0	1,463.4	1,431.2	1,415.2	1,410.4	1,406.5	1,396.7	1,394.2
	5.B.1. Cropland remaining Cropland	Total	Gg-CO_2	1,603.0	1,558.9	1,532.4	1,499.4	1,483.0	1,478.1	1,474.1	1,463.9	1,461.2
		Living Biomass	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Dead Wood	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Litter	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Mineral soil	Gg-CO_2	70.7	70.0	69.0	68.2	67.8	67.7	67.6	67.2	67.0
		Organic soil	Gg-CO_2	1,532.3	1,489.0	1,463.4	1,431.2	1,415.2	1,410.4	1,406.5	1,396.7	1,394.2
	5.B.2. Land converted to Cropland	Total	Gg-CO_2	2,585.2	763.2	334.8	255.1	232.7	383.0	283.7	245.2	180.0
		Living Biomass	Gg-CO_2	1,507.5	307.6	98.8	118.5	129.1	235.9	169.0	146.4	112.1
		Dead Wood	Gg-CO_2	405.0	82.5	26.5	31.6	29.1	66.1	51.3	44.0	27.5
		Litter	Gg-CO_2	194.5	39.6	12.7	15.2	14.0	31.9	24.9	21.4	13.4
		Mineral soil	Gg-CO_2	478.2	333.5	196.7	89.8	60.5	49.1	38.5	33.5	27.1
		Organic soil	Gg-CO_2	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO

7.5.1. Cropland remaining Cropland (5.B.1)

a） ***Source/Sink 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 FY2012 were 1,461 Gg-CO_2 (excluding 247 Gg-CO_2 of CO_2 emissions resulting from lime application to agricultural soils); this represents a decrease of 8.8% below the FY1990 value and a decrease of 0.2% below the FY2011 value.

With respect to living biomass, the carbon stock change in perennial tree crops (fruit trees) is the subject of estimation according to the *GPG-LULUCF*. However, in Japan, tree growth is limited by trimming in order to have high productivity by keeping the tree height low, and by pruning lateral branches to improve tree shape. Therefore, carbon accumulation because of tree growth cannot be expected, and the annual carbon fixing volume of perennial tree crops in all orchards is stated as "NA."

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 3.3.1.2.1 in the *GPG-LULUCF*. Thus, the carbon stock changes are reported as "NA".

Carbon stock changes in mineral soils and CO_2 emissions from organic soils were estimated by applying Tier 1 and Tier 2. The area of cropland remaining croplands within the past 20 years was shown in Table 7-21. In addition, this area contained that of organic soils.

Table 7-21 Areas of cropland remaining cropland within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Cropland remaining Cropland	kha	4,103.3	4,057.6	4,001.6	3,952.9	3,931.9	3,924.8	3,918.2	3,892.4	3,882.8

Moreover, the carbon stock changes in mineral soils in this category will be estimated by using Tier 3 in the near future. Hence, it should be noted that the Tier 1 estimates in this submission were provisional values.

b） ***Methodological Issues***

1） 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 1 estimation method described in section 3.3.1.2 in *GPG-LULUCF*. The estimation equation is as follows:

$$\Delta C_{MS} = \sum_{c,s,i} [(SOC_0 - SOC_{(0-T)}) \times A]_{c,s,i} / T$$
$$SOC = SOC_{ref} \times F_{LU} \times F_{MG} \times F_I$$

ΔC_{MS} : Carbon stock changes in mineral soils [t-C/yr]
SOC : Carbon stock in mineral soils per area [t-C/ha]
SOC_{ref} : Reference carbon stock (determined for each climate zone and soil type in each land use) [t-C/ha]
A : Area of cropland remaining cropland within 20 years [ha]

F_{LU} : Carbon stock change factor in connection with land use

F_{MG} : Carbon stock change factor in connection with management

F_I : Carbon stock change factor in connection with input

T : Transition period (20 years)

c : Climate zone

s : Soil type

i : Type of land use

There are data of areas of each climate zone, soil type and form of farming (type of land use) for 1992 and 2001 (Takada et al, 2009) in Japan. The carbon stock changes in this category were estimated by applying the data of areas referred above. The estimation method is as follows:

1. Estimate soil carbon stocks per area of each type of land use and each soil type in 1992 and 2001,
2. Estimate soil carbon stock changes per year per area of each type of land use and soil by differences of the soil carbon stocks per area in 1992 and 2001 estimated above,
3. Set the soil carbon stock factor for total cropland area by weighted average by areas of each type of land use and soil to the values estimated in 2,
4. Apply the soil carbon stock change factor between 1992 and 2001 to the carbon stock changes from 1990 to the latest year, multiply cropland area to the factors and estimate carbon stock changes in cropland.

➢ ***Carbon stock changes in organic soils***

Carbon stock changes in organic soils were estimated by applying Tier 1 estimation method described in section 3.3.1.2.1.1 in *GPG-LULUCF*. Tier 2 method was applied to land-use categories 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 [t-C/yr]

A : Area of organic soils [ha]

EF : Emission factor [t-C/ha/yr]

c : Climate zone

● ***Parameters***

➢ ***Reference carbon stocks in mineral soils***

Default values described in GPG-LULUCF (Table 3.3.3) were applied. Areas were divided according to temperatures and precipitations described in figure 3.1.3 in chapter 3 of GPG-LULCF. As a result, in Japan, Hokkaido belongs to cold temperate (annual average temperature is 0 to 10 degree Celsius), and most areas other than Hokkaido belong to warm temperate (annual average temperature is 10 to 20 degree Celsius). With respect to precipitations, almost all national areas belong to moist (annual precipitation is more than 1,000m). Hence, cold temperate moist was applied to Hokkaido, and warm temperate moist was applied to areas other than Hokkaido.

Table 7-22 Relationship of soil classification between Japan's agricultural land and default values in *GPG-LULUCF*

Classification of soils in agricultural land	Classification in GPG-LULUCF	Default SOC [t-C/ha]	
		Warm temperate, moist	Cold temperate, moist
Lithosols, Cambisols, Fluvisols,	HAC soils	88	95
Red Soils, Yellow Soils, Dark Red Soils	LAC soils	63	85
Sand-Dune Regosols	Sandy soils	34	71
Andisols, Wet Andisols, Gleyed Andosols	Volcanic soils	80	130
Gray Upland Soil, Gley Upland Soils, Gleysols,	Wetland soils	88	87

Reference) GPG-LULUCF Chp.3 Table 3.3.3

- ***Soil carbon stock change factor in mineral soils***

Three kinds of carbon stock change factors were multiplied to reference carbon stocks in accordance with Tier 1 method which supposed that soil carbon stocks were changed depending on land use, management and input. In addition, there is little information on differences of management and input in each region in Japan, and it is difficult to set the threshold across the factors set by default in time series. Hence, the same carbon stock change factors were applied to all nation and time series. The applied carbon stock change factors were as follows:

Table 7-23 Carbon stock change factors applied to the estimation

Type of land use	Factor	Set value	Basis	Reference
Rice field	F-LU	1.1	Paddy rice	GPG-LULUCF Table 3.3.4
	F-MG	-	Factors for tillage and input are not applied to paddy rice.	
	F-I	-		
Upland field	F-LU	0.71	Longterm cultivated Temperate Wet	
	F-MG	1.0	Full Tillage	
	F-I	1.0	Set by the value of Medium Input	
Orchard	F-LU	1.0	Perennial/Tree Crop	2006GL Vol.4 Table5.5
	F-MG	1.0	Full Tillage	GPG-LULUCF Table 3.3.4
	F-I	1.0	Set by the value of Medium Input	
Pasuture land	F-LU	1.0	The value is 1.0 in all grassland	GPG-LULUCF Table 3.4.5
	F-MG	1.14	Improved grassland Temperate	
	F-I	1.0	Set by the value of Nomal.	

- ***CO_2 emission factors from organic soils***

The following CO_2 emission factors from organic soils were applied to the estimation.

Table 7-24 CO_2 emission factors resulting from cultivation of organic soils

Type of land use	Climate zone	Emission factors [tC/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 (GPG-LULUCF Table 3.3.5)
Orchard	Cold temperate	1.0	Default value (GPG-LULUCF Table 3.3.5)[3)]
	Warm temperate	10.0	

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 GPG-LULUCF; hence, the country-specific factor in cold temperate was applied as substitute.
3) The default factor for upland field was applied under determination that form of agricultural management was similar with upland field.

● ***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 7-25) from area of cropland remaining cropland within 20 years estimated by applying areas reported in the *Statistics of Cultivated and Planted Area* (Table 7-21).

➢ ***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 cold temperate (Hokkaido) and warm temperate (other than Hokkaido) were estimated separately. The areas of organic soils in Japan by estimating the method mentioned above are as follows:

Table 7-25 Areas of organic soils in cropland

Category			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total			kha	192.8	188.6	186.2	181.6	179.0	178.4	177.7	176.3	176.0
	Rice field		kha	166.5	163.1	160.9	156.5	154.0	153.4	152.8	151.4	151.1
		Hokkaido	kha	49.2	48.9	49.4	48.3	47.5	47.3	47.1	46.7	46.6
		Other than Hokkaido	kha	117.4	114.2	111.5	108.2	106.5	106.1	105.6	104.7	104.5
	Upland field		kha	24.7	24.2	24.3	24.2	24.1	24.1	24.1	24.0	24.0
		Hokkaido	kha	17.5	17.4	17.7	17.6	17.6	17.6	17.6	17.5	17.5
		Other than Hokkaido	kha	7.1	6.9	6.6	6.5	6.5	6.5	6.5	6.5	6.5
	Orchard		kha	1.5	1.3	1.0	0.9	0.9	0.9	0.9	0.9	0.9
		Hokkaido	kha	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		Other than Hokkaido	kha	1.5	1.2	0.9	0.9	0.8	0.8	0.8	0.8	0.8

In addition, the areas of organic soil reported under the LULUCF sector were not the same as the areas reported under the agriculture sector because three-year averages were used to estimate the areas of organic soils which are used as activity data in the agriculture sector.

c) *Uncertainties and Time-series Consistency*

● ***Uncertainty Assessment***

Uncertainties of the parameters and the activity data for mineral and organic soils were individually assessed on the basis of field study results, expert judgment, or the default values described in the *GPG-LULUCF*. The uncertainty was estimated as 19% for the entire emission from the cropland remaining cropland.

● ***Time-series Consistency***

Time-series consistency for this category is ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

● ***Areas of cropland remaining cropland***

Areas of cropland remaining cropland were estimated by subtracting areas of land converted to cropland from the total cropland areas. This time, areas of forest land converted to cropland were revised due to revision of ARD ratios. As a result, areas of cropland remaining cropland were also recalculated. In addition, a lack of a part of data in soil areas per land category in 2001, which was used for Tier 1 estimation, was fulfilled. Hence, carbon stock changes in mineral soils in this category were recalculated.

f） ***Source-/Sink-specific Planned Improvements***

● ***Carbon Stock Changes in Mineral Soils in "Cropland remaining Cropland"***

Research and data collection activities for estimating carbon stock changes in mineral soils in cropland have been in progress in order to use higher tier to which Japan's country-specific circumstances were reflected. Japan is planning to change reporting of the carbon stock changes in mineral soils in this category from Tier 1 to the higher tier in its future submission when application of the higher tier becomes possible.

● ***Categorization of cultivation abandonment areas***

Japan has started examining re-categorization of cultivation abandonment areas as a sub-category under cropland. As of now, it is necessary to further examine a definition and method of identifying converted areas in the case of the re-categorization; therefore, further discussion on this issue will continue.

7.5.2. Land converted to Cropland (5.B.2)

a） ***Source/Sink 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 FY2012 is 52.9kha, which represents 0.1% of the national total area.

The emissions from this subcategory in FY2012 were 180 Gg-CO_2 (excluding 4.0 Gg-CO_2 eq. of N_2O emissions resulting from disturbance associated with land-use conversion to cropland and 247 Gg-CO_2 of CO_2 emissions resulting from lime application to agricultural soils); this represents a decrease of 93.0% below the FY1990 value and a decrease of 26.6% below the FY2011 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.

With respect to dead organic matter and soils, their carbon stock changes as a result of land-use conversion from other land uses to cropland are estimated. CO_2 emissions from organic soils are subject to estimation when tillage and drainage are implemented. In the case of organic soils in forest land converted to cropland, their carbon stock changes were reported as “NO” because conversion of organic soil areas in forest land to cropland was not implemented in Japan. CO_2 emissions from organic soils in cropland converted from land-use categories other than forest land 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.

$$\Delta C = \Delta C_i + \Delta C_j$$
$$\Delta C_i = A\ (CR_a - CR_i) \times CF$$
$$\Delta C_j = A \times CR_j \times CF$$

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 7-7 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. Parameters on growth in orchard continue to be examined for setting country-specific parameters based on data on composition of major fruit trees and on growth periods.

➢ ***Carbon Fraction of Dry Matter***

0.5 (t-C/t-d.m.) (*GPG-LULUCF*, default value)

● ***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 11.3.2.3 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 5.B SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Cropland" is not the annually converted area in FY2012 but the sum of annually converted areas during the past 20 years.

Table 7-26 Area of land converted to cropland (single year)

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Cropland	kha	8.6	4.4	3.1	2.0	1.5	1.3	1.3	1.4	5.1
Forest land converted to Cropland	kha	7.3	1.5	0.5	0.6	0.5	1.2	0.9	0.8	0.5
Rice field	kha	0.012	0.019	0.003	0.000	0.047	0.039	0.091	0.081	0.073
Upland field	kha	7.3	1.5	0.5	0.6	0.5	1.2	0.8	0.7	0.4
Orchard	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Grassland converted to Cropland	kha	0.002	0.022	0.012	0.027	0.005	0.004	0.0003	0.0009	0.0007
Wetlands converted to Cropland	kha	0.34	0.03	0.07	0	0.47	0	0	0	0
Settlements converted to Cropland	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to Cropland	kha	0.9	2.8	2.5	1.4	0.5	0.1	0.33	0.61	4.61
Rice field	kha	0.2	1.1	1.3	0.3	0.1	0.0	0.06	0.16	3.79
Upland field	kha	0.7	1.8	1.2	1.1	0.3	0.0	0.28	0.46	0.82
Orchard	kha	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 3.4.2.2.1 in the *GPG-LULUCF*. 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 "NE", because suitable knowledge for estimating carbon stock changes for this land-use conversion was not available.

● ***Parameters***

Average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 7-8 and 7-9. 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***

Carbon stock changes in soils were calculated by applying the Tier 2 estimation method in accordance with the estimation method for land converted to cropland (*GPG-LULUCF*, page 3-89) using the values of carbon stock in soils which are country specific or obtained by the CENTURY-jfos model.

$$\Delta C_i = A_i \times (C_{after,i} - C_{before,i}) / 20$$

ΔC_i : Annual change in carbon stocks in soils in converted land [t-C/yr]

A_i : Area converted to land-use category *i* within the past 20 years [ha]

$C_{after,\,i}$: Average carbon stocks per unit area in land-use category *i* after conversion [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

● ***Parameters***

Average soil carbon stocks in each land-use category shown in Table 7-10 were used. For reference, soil carbon stocks of cropland (rice field, upland field and orchard) are described below in detail:

➢ ***Soil carbon stocks in Rice field, Upland field and Orchard***

For the carbon stocks in rice fields, upland fields and orchard soils, the country-specific soil survey data were applied. As soil carbon stocks per unit area vary from one soil group to another (such as Andosols, Gray lowland soils and Gley soils), the average soil carbon stocks in rice field, upland field and orchard are calculated by averaging the soil carbon stock data per unit area at 0-30 cm depth weighted by the area for each soil group.

Table 7-27 Soil carbon stocks in rice field

Soil Type	Area [ha]	Proportion	Carbon Stock / ha [t-C/ha]	Carbon Stock [t-C]
Lithosols	*	---	*	---
Sand-Dune Regosols	*	---	89.04	---
Andisols	17,169	0.6%	125.24	2,150,246
Wet Andosols	274,319	9.5%	113.68	31,184,584
Gleyed Andosols	50,760	1.8%	101.74	5,164,322
Cambisols	6,640	0.2%	59.48	394,947
Gray Upland Soils	79,236	2.7%	60.37	4,783,477
Gley Upland Soils	40,227	1.4%	60.71	2,442,181
Red Soils	*	---	*	---
Yellow Soils	144,304	5.0%	63.21	9,121,456
Dark Red Soils	1,770	0.1%	56.26	99,580
Fluvisols	141,813	4.9%	59.71	8,467,654
Gleysols	1,056,571	36.6%	61.59	65,074,208
Gleysols	889,199	30.8%	64.83	57,646,771
Muck Soils	75,944	2.6%	91.89	6,978,494
Histosols	109,465	3.8%	114.95	12,583,002
Total	2,887,417	100.0%		206,090,923
Average			80.19	
Weighted Average			71.38	Applied Value

*: Data difficult to obtain with high accuracy.

Reference: M. Nakai, unpublished data, National Institute for Agro-Environmental Sciences (NIAES) (data in 0 to 30 cm depth)

Table 7-28 Soil carbon stocks in upland field

Soil Type	Area [ha]	Proportion	Carbon Stock / ha [t-C/ha]	Carbon Stock [t-C]
Lithosols	7,148	0.4%	69.25	494,999
Sand-Dune Regosols	22,297	1.2%	21.49	479,163
Andisols	851,061	46.5%	109.15	92,893,308
Wet Andosols	72,195	3.9%	149.51	10,793,874
Gleyed Andosols	1,850	0.1%	120.98	223,813
Cambisols	287,464	15.7%	65.16	18,731,154
Gray Upland Soils	71,855	3.9%	79.77	5,731,873
Gley Upland Soils	4,324	0.2%	*	---
Red Soils	25,243	1.4%	42.23	1,066,012
Yellow Soils	105,641	5.8%	47.13	4,978,860
Dark Red Soils	29,130	1.6%	45.15	1,315,220
Fluvisols	231,051	12.6%	50.05	11,564,103
Gleysols	75,095	4.1%	53.75	4,036,356
Gleysols	13,163	0.7%	65.94	867,968
Muck Soils	1,673	0.1%	78.72	131,699
Histosols	32,316	1.8%	184.91	5,975,552
Total	1,831,506	100.0%		159,283,954
Average			78.88	
Weighted Average			86.97	Applied Value

*: Data t difficult to obtain with high-accuracy.

Reference: M. Nakai, unpublished data, NIAES (data in 0 to 30 cm depth)

Table 7-29 Soil carbon stocks in orchard

Soil Type	Area [ha]	Proportion	Carbon Stock / ha [t-C/ha]	Carbon Stock [t-C]
Lithosols	7,682	1.9%	66.48	510,699
Sand-Dune Regosols	1,897	0.5%	27.77	52,680
Andisols	86,083	21.3%	119.03	10,246,459
Wet Andosols	2,530	0.6%	103.82	262,665
Gleyed Andosols	*	---	115.08	---
Cambisols	148,973	36.9%	68.35	10,182,305
Gray Upland Soils	6,424	1.6%	70.55	453,213
Gley Upland Soils	*	---	*	---
Red Soils	19,937	4.9%	63.68	1,269,588
Yellow Soils	75,973	18.8%	64.48	4,898,739
Dark Red Soils	6,141	1.5%	54.61	335,360
Fluvisols	35,261	8.7%	69.32	2,444,293
Gleysols	10,075	2.5%	57.35	577,801
Gleysols	2,065	0.5%	*	---
Muck Soils	135	0.0%	59.44	8,024
Histosols	130	0.0%	*	---
Total	403,306	100.0%		31,241,826
Average			72.30	
Weighted Average			77.46	Applied Value

*: Data difficult to obtain with high accuracy.

Reference: M. Nakai, unpublished data, NIAES (data in 0 to 30 cm depth)

- ***Activity Data (Area)***

Areas of land converted to cropland during the past 20 years are assumed as the sum of the areas of annually converted land to cropland during the past 20 years. The assumed areas are applied to the estimation of the carbon stock changes in soils in land converted to cropland. The areas are shown in Table 7-30 below.

Table 7-30 Area of land converted to cropland within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Cropland	kha	493.1	319.7	183.7	108.5	74.8	65.4	58.1	53.4	52.9
Forest land converted to Cropland	kha	279.7	204.0	121.8	55.9	37.3	30.3	23.9	20.7	16.7
Rice field	kha	279.7	204.0	121.8	55.9	37.3	30.3	23.9	20.7	16.7
Upland field	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Orchard	kha	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	0.4
Wetlands converted to Cropland	kha	11.9	3.9	2.0	1.2	1.2	1.1	0.7	0.7	0.6
Settlements converted to Cropland	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to Cropland	kha	193.0	107.1	59.2	50.9	35.8	33.6	33.0	31.6	35.2
Rice field	kha	27.7	16.2	11.2	9.9	11.6	11.4	11.3	10.9	14.5
Upland field	kha	165.2	90.9	48.0	41.1	24.2	22.1	21.7	20.7	20.8
Orchard	kha	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, and soil were individually assessed on the basis of field study results, expert judgment, or the default values described in the *GPG-LULUCF*. The uncertainty was estimated as 25% for the entire emission from the land converted to cropland. More detailed information on the uncertainty assessment is described in Annex 7. Uncertainty estimates of some major parameters, which were used for the uncertainty assessment for this category, are shown in Table 7-31 as an example.

Table 7-31 Uncertainty estimates regarding major parameters in the cropland category

Land-use category		Uncertainty [%]	Country Specific (CS) or Default (D)	Note
Cropland Area	Rice Field	0.15	CS	Original uncertainty of statistics
	Upland Field	0.27	CS	

● ***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 7.5.2.b)1), time-series consistency for this subcategory is basically ensured.

d） *Source-/Sink-specific QA/QC and Verification*

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） *Source-/Sink-specific Recalculations*

● ***Areas of forest land converted to cropland***

Areas of forest land converted to cropland were recalculated because areas of deforestation (D areas) under Article 3, paragraph 3, of the Kyoto Protocol were recalculated. For further information on recalculation of D areas, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

● ***Carbon Stock Changes in Living Biomass in Forest land converted to Cropland***

Living biomass accumulation in forest land before conversion from FY1990 to FY2004 were estimated by extrapolation of the trend of living biomass accumulation per area in the D area during the period between FY2005 and the latest year. As a result of recalculation of D areas and living biomass accumulation in D areas, the living biomass accumulation did not have a trend depending on time series. Hence, the biomass accumulations in the past were estimated by averaging those from FY2008 to FY2012. As a result, carbon stock changes in living biomass in forest land converted to cropland were recalculated.

- ***Carbon Stock Changes in Dead Organic Matter and Mineral Soils in Forest land converted to Cropland***

As a result of revision of Forest Registers, carbon stocks in dead organic matter and mineral soils in forest land before conversion from 2008 to 2001 were revised. As a result, carbon stock changes in forest land converted to cropland were recalculated.

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

- ***Carbon Stock Changes in living biomass in land converted to orchard***

When orchards are newly established in land converted to cropland, trees that newly planted in the orchards absorb CO2 and fix carbon. Japan is investigating the data for estimating the carbon stock changes in this category in order to estimate the carbon stock changes in the future.

- ***Carbon Stock Changes in Mineral Soils in "Land converted to Cropland"***

Research and data collection activities for estimating carbon stock changes in mineral soils in agricultural land in Japan and for estimating N_2O emissions relevant to the carbon stock changes have been in progress in order to use higher tier to which Japan's country-specific circumstances were reflected. Japan is planning to change reporting of the carbon stock changes in mineral soils in this category from Tier 1 to the higher tier in its future submission when application of the higher tier becomes possible.

- ***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.

7.6. Grassland (5.C)

Grassland is generally covered with perennial pasture and is used mainly for harvesting fodder or grazing. In FY2012, 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 0.04 million ha. The net removals from this category in FY2012 were 116 Gg-CO_2 (excluding 247 Gg-CO_2 of CO_2 emissions resulting from lime application to agricultural soils); this represents a decrease of 49.8% below the FY1990 value and a decrease of 12.8% below the FY2011 value.

This section divides grassland into two subcategories, "Grassland remaining Grassland (5.C.1.)" and "Land converted to Grassland (5.C.2.)", and describes them separately in the following subsections.

Table 7-32 Emissions and removals from grassland resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.C. Grassland	Total	Gg-CO_2	-231.0	-339.9	-281.9	-200.7	-161.4	-139.5	-111.9	-133.1	-116.0
		Living Biomass	Gg-CO_2	77.3	-14.1	-26.6	-29.9	-17.2	-8.1	6.2	-10.4	0.3
		Dead Wood	Gg-CO_2	57.0	12.5	4.1	4.4	6.9	9.3	12.5	6.0	6.7
		Litter	Gg-CO_2	27.4	6.0	2.0	2.1	3.3	4.5	6.1	2.9	3.3
		Mineral soil	Gg-CO_2	-392.7	-344.2	-261.3	-177.2	-154.4	-145.1	-136.6	-131.6	-126.2
		Organic soil	Gg-CO_2	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I	NO,NE.NA,I
	5.C.1. Grassland remaining Grassland	Total	Gg-CO_2	NO,NE,NA	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NO,NE	NA,NO,NE
		Living Biomass	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Dead Wood	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Litter	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Mineral soil	Gg-CO_2	NA	NA	NA	NA	NA	NA	NA	NA	NA
		Organic soil	Gg-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
	5.C.2. Land converted to Grassland	Total	Gg-CO_2	-231.0	-339.9	-281.9	-200.7	-161.4	-139.5	-111.9	-133.1	-116.0
		Living Biomass	Gg-CO_2	77.3	-14.1	-26.6	-29.9	-17.2	-8.1	6.2	-10.4	0.3
		Dead Wood	Gg-CO_2	57.0	12.5	4.1	4.4	6.9	9.3	12.5	6.0	6.7
		Litter	Gg-CO_2	27.4	6.0	2.0	2.1	3.3	4.5	6.1	2.9	3.3
		Mineral soil	Gg-CO_2	-392.7	-344.2	-261.3	-177.2	-154.4	-145.1	-136.6	-131.6	-126.2
		Organic soil	Gg-CO_2	NO	NO	NO	NO	NO	NO	NO	NO	NO

7.6.1. Grassland remaining Grassland (5.C.1)

a) ***Source/Sink 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 3.4.1.1.1.1 in the *GPG-LULUCF*.

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 3.4.1.2.1 in the *GPG-LULUCF*, 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 method same as cropland remaining cropland, but the carbon stock changes in pasture land did not occur because the parameters applied in the time series did not change under the Tier 1 method. Hence, the carbon stock changes were reported as "NA". On the other hand, 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 3.4.5 of the *GPG-LULUCF*, 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". CO_2 emissions resulting from tillage and drainage of organic soils in grassland remaining grassland are reported as "NO" because the tillage and drainage resulting from renewal of pasture land that cause CO_2 emissions are not implemented in general.
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 7-33 Areas of grassland remaining grassland within the past 20 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Grassland remaining Grassland		kha	876.8	907.3	931.5	949.9	954.0	955.3	956.0	920.0	920.1
	Pasture land	kha	501.8	546.4	564.7	573.4	577.5	578.9	579.6	580.0	580.1
	Grazed meadow	kha	105.0	100.9	96.8	96.5	96.4	96.4	96.4	96.4	96.4
	Wild land	kha	270.0	260.0	270.0	280.0	280.0	280.0	280.0	243.6	243.6

b） ***Source-/Sink-specific Recalculations***

- ***Areas of grassland remaining grassland***

Areas of grazed meadow and wild land were separately reported in the *Land Use Status Survey* by 2010, but these areas came to be reported in a lump from 2011. Hence, the area of wild land in 2011 was changed from a statistical data to estimated data, and the area of grassland remaining grassland in 2011 was recalculated.

- ***CO_2 emissions from organic soils in grassland remaining grassland***

In the previous submission, CO_2 emissions from organic soils in grassland remaining grassland were estimated by applying Tier 1. However, tillage and drainage resulting from renewal of pasture land that cause CO_2 emissions are not implemented in general in Japan, so reporting the CO_2 emissions from organic soils in grassland remaining grassland was changed from estimates to the notation key "NO".

c） ***Source-/Sink-specific Planned Improvements***

- ***Carbon Stock Changes in Mineral Soils in "Grassland remaining Grassland"***

Carbon stock changes in mineral soils in this category are reported as "NA" by applying Tier 1. However, research projects on soil carbon stocks in pasture land are in progress in order to use higher tier to which Japan's country-specific circumstances were reflected. Therefore, Japan is planning to change reporting of the carbon stock changes in mineral soils in this category from Tier 1 to the higher tier in its future submission when application of the higher tier becomes possible.

- ***CO_2 Emissions from Cultivated Organic Soils in Grassland***

With respect to CO_2 emissions from organic soils in grassland, CO_2 emissions from organic soils are being examined in a cross-cutting manner through the LULUCF sector, including the emissions from cropland.

7.6.2. Land converted to Grassland (5.C.2)

a） ***Source/Sink 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 FY2012 was 116 Gg-CO_2 (excluding 247 Gg-CO_2 of CO_2 emissions resulting from lime application to agricultural soils); this represents a decrease of 49.8% below the FY1990 value and a decrease of 12.8% below the FY2011 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 “NE” or “NA” 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 and wetlands. 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 7.5.2.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 Tables 7-7a and 7-7b 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***

0.5 [t-C/t-d.m.] (*GPG-LULUCF*, default value)

● ***Activity Data (Area)***

As shown in Table 7-4, 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 7.5.2.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 5.C SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Grassland” is not the annually converted area in FY2012 but the sum of annually converted areas during the past 20 years.

Table 7-34 Area of land converted to grassland (single year)

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Grassland		kha	4.0	1.9	1.7	2.4	1.4	1.0	1.2	1.1	0.9
	Forest land converted to Grassland	kha	1.0	0.2	0.1	0.1	0.1	0.2	0.2	0.1	0.1
	Cropland converted to Grassland	kha	0.9	0.6	1.0	1.7	0.8	0.7	0.7	0.6	0.4
	Wetlands converted to Grassland	kha	0.12	0.01	0.03	0.00	0.20	0.00	0.00	0.00	0.00
	Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land converted to Grassland	kha	1.9	1.1	0.6	0.6	0.2	0.1	0.2	0.4	0.4

Table 7-35 Area of land converted to grassland within the past 5 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Grassland		kha	27.2	12.2	8.4	9.3	9.6	8.4	7.1	6.1	5.5
	Forest land converted to Grassland	kha	4.9	1.9	0.7	0.3	0.5	0.6	0.7	0.8	0.8
	Cropland converted to Grassland	kha	6.5	3.4	4.5	6.2	6.4	5.7	4.6	3.8	3.2
	Wetlands converted to Grassland	kha	0.32	0.07	0.03	0	0.20	0.20	0.20	0.20	0.20
	Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land converted to Grassland	kha	15.4	6.8	3.2	2.8	2.6	1.9	1.6	1.3	1.4

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 Guideline 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 7.5.2.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” and “NE”, respectively[7], for similar reasons as described in section 7.5.2.b)2).

- ***Parameters***

The average carbon stocks in dead wood and litter in forest land before conversion are shown in Tables 7-8 and 7-9. 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 3.4.2.2.1 in the *GPG-LULUCF*.

- ***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 7-36.

Table 7-36 Areas of land converted to grassland within the past 20 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Grassland		kha	144.8	114.3	80.0	57.2	43.8	39.9	37.1	35.2	33.2
	Forest land converted to Grassland	kha	30.7	25.5	16.7	7.8	5.4	4.4	3.6	3.1	2.6
	Cropland converted to Grassland	kha	25.2	21.2	19.8	20.7	19.4	19.0	18.8	18.5	18.0
	Wetlands converted to Grassland	kha	0.8	0.9	0.7	0.4	0.5	0.4	0.3	0.3	0.3
	Settlements converted to Grassland	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Other land converted to Grassland	kha	88.1	66.8	42.9	28.2	18.5	16.1	14.4	13.2	12.3

[7] Cropland in the Japanese statistics includes pasture land which falls into grassland.

3） *Carbon Stock Change in Soils in "Land converted to Grassland"*

● ***Estimation Method***

➢ ***Carbon Stock Changes in Mineral Soils***

Carbon stock changes in mineral soils in grassland converted from forest land and wetlands were estimated by applying the estimation method same as section 7.5.2.b)3). Carbon stock changes in mineral soils in cropland converted to grassland were estimated by applying the estimation method same as section 7.5.1.b)1). The carbon stock changes in settlements converted to grassland were reported as "NO" because the conversion was not implemented in general in Japan.. The carbon stock changes in other land converted to grassland were reported as "NE" because they are not estimated.

➢ ***CO_2 emissions from organic soils***

CO_2 emissions from organic soils in this category were reported by applying appropriate notation keys as explained in section 7.6.2.a).

● ***Parameters***

➢ ***Carbon stocks in mineral soils in grassland converted from forest land and wetlands***

Carbon stocks in mineral soils in grassland (pasture land) converted from forest land and wetland were determined based on data from the country-specific soil survey. With respect to pasture land, although it is difficult to obtain area data by soil types, it could be viewed that the area by soil types and the number of samples by soil types have a high correlation. Therefore, the area data are calculated by averaging and weighting the soil carbon stock data by the number of samples for each soil group.

Table 7-37 Soil carbon stocks in grassland

Soil Type	Area [ha]	Proportion	Carbon Stock / ha [t-C/ha]	Carbon Stock [t-C]
Lithosols	*	---	*	---
Sand-Dune Regosols	140	0.6%	79.28	11,099
Andisols	11,364	48.8%	152.19	1,729,487
Wet Andosols	459	2.0%	207.40	95,197
Gleyed Andosols	*	---	*	---
Cambisols	4,071	17.5%	101.27	412,270
Gray Upland Soils	2,008	8.6%	126.44	253,892
Gley Upland Soils	228	1.0%	110.51	25,196
Red Soils	*	---	*	---
Yellow Soils	796	3.4%	74.36	59,191
Dark Red Soils	695	3.0%	54.55	37,912
Fluvisols	2,658	11.4%	107.69	286,240
Gleysols	215	0.9%	78.76	16,933
Gleysols	*	---	*	---
Muck Soils	*	---	*	---
Histosols	663	2.8%	325.18	215,594
Total	23,297	100.0%		3,143,012
Average			128.88	
Weighted Average			134.91	Applied Value

*: Data difficult to obtain with high accuracy.

Reference: M. Nakai, unpublished data, NIAES (data in 0 to 30 cm depth)

➢ ***Carbon stocks in mineral soils in cropland converted to grassland***

Carbon stocks in mineral soils in cropland converted to grassland were set by applying reference carbon stocks and carbon stock change factors described in section 7.5.1.b)1).

● ***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. In addition, areas of organic soils were regarded as included in grassland remaining grassland. The areas are shown in Table 7-36.

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 *GPG-LULUCF*. The uncertainty was estimated as 97% for the entire removal from the land converted to grassland. More detailed information on the uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be calculated in future submissions after investigation is completed.

● ***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 7.5.2.b)1), time-series consistency for this subcategory is basically ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

● ***Areas of forest land converted to grassland***

Areas of forest land converted to grassland were recalculated because areas of deforestation (D areas) under Article 3, paragraph 3, of the Kyoto Protocol were recalculated. For further information on recalculation of D areas, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

● ***Carbon Stock Changes in living biomass in forest land converted to grassland***

The estimation method on living biomass accumulation in forest land before conversion was revised; hence, the carbon stock changes in living biomass in forest land converted to grassland were recalculated. For further information on revision of the estimation method on the living biomass accumulations in forest land before conversion, see section 7.5.2.e) in this chapter.

● ***Carbon Stock Changes in Dead Organic Matter and Mineral Soils in Forest land converted to Grassland***

As a result of revision of Forest Registers, carbon stocks in dead organic matter and mineral soils in forest land before conversion from 2008 to 2001 were revised. As a result, carbon stock changes in forest land converted to grassland were recalculated.

● ***Carbon stock changes in living biomass in cropland converted to grassland***

Carbon stock changes in living biomass in orchard converted to grassland were recalculated because of revision of the incorrect unit of a parameter on biomass stock in orchard before conversion.

- ***Areas and carbon stock changes in settlements converted to grassland***

Land conversion from settlements to grassland is not implemented in general in Japan; hence, reporting areas and carbon stock changes in settlements converted to grassland was changed from “IE” to “NO”.

f) ***Source-/Sink-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”***

Research and data collection activities for estimating carbon stock changes in mineral soils in grassland have been in progress in order to use higher tier to which Japan’s country-specific circumstances were reflected. Japan is planning to change reporting of the carbon stock changes in mineral soils in this category from Tier 1 to the higher tier in its future submission when application of the higher tier becomes possible.

- ***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.

7.7. Wetlands (5.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 *GPG-LULUCF* divides wetlands into two large groups: peat land and flooded land.

In FY2012, 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 FY2012 were 31.8 Gg-CO_2. This represents a decrease of 65.0% below the FY1990 value and a decrease of 27.6% below the FY2011 value.

This section divides wetlands into two subcategories, "Wetlands remaining Wetlands (5.D.1.)" and "Land converted to Wetlands (5.D.2.)", and describes them separately in the following subsections.

Table 7-38 Emissions and removals in wetlands resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.D. Wetlands	Total	Gg-CO_2	90.9	360.3	428.7	14.7	34.5	73.4	51.5	44.0	31.8
		Living Biomass	Gg-CO_2	65.3	258.6	307.8	10.6	25.9	52.0	35.6	30.5	23.4
		Dead Wood	Gg-CO_2	17.3	68.7	81.7	2.8	5.8	14.4	10.7	9.1	5.7
		Litter	Gg-CO_2	8.3	33.0	39.2	1.3	2.8	7.0	5.2	4.4	2.8
		Soil	Gg-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
	5.D.1. Wetlands remaining Wetlands	Total	Gg-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
		Living Biomass	Gg-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
		Dead Wood	Gg-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
		Litter	Gg-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
		Soil	Gg-CO_2	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
	5.D.2. Land converted to Wetlands	Total	Gg-CO_2	90.9	360.3	428.7	14.7	34.5	73.4	51.5	44.0	31.8
		Living Biomass	Gg-CO_2	65.3	258.6	307.8	10.6	25.9	52.0	35.6	30.5	23.4
		Dead Wood	Gg-CO_2	17.3	68.7	81.7	2.8	5.8	14.4	10.7	9.1	5.7
		Litter	Gg-CO_2	8.3	33.0	39.2	1.3	2.8	7.0	5.2	4.4	2.8
		Soil	Gg-CO_2	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE

7.7.1. Wetlands remaining Wetlands (5.D.1)

a) ***Source/Sink Category Description***

This subcategory deals with carbon stock changes in wetlands which have remained as wetlands during the past 20 years.

Carbon stock changes in organic soils that are managed for peat extraction are reported as "NO", since peat extraction is not carried out in Japan. (Default value for Japan is not provided in the *GPG-LULUCF* p.3.282 Table 3A3.3).

"Flooded land remaining flooded land" is not calculated at the present time as this will be treated in an appendix and reported as "NE".

Table 7-39 Areas of wetlands remaining wetlands within the past 20 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Wetlands remaining Wetlands		kha	1,289.9	1,293.7	1,321.4	1,317.1	1,309.4	1,309.5	1,309.6	1,319.8	1,321.0
	Organic soils managed for peat extraction	kha	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Flooded land	kha	1,289.9	1,293.7	1,321.4	1,317.1	1,309.4	1,309.5	1,309.6	1,319.8	1,321.0

b) ***Source-/Sink-specific Recalculations***

● ***Areas of wetlands remaining wetlands***

Areas of wetlands remaining wetlands are estimated by subtracting areas of land converted wetlands and those of urban parks in river banks and green areas along rivers and erosion control. This time, areas of forest land converted to wetlands, urban parks in river banks and green areas along rivers and erosion control were revised. As a result, the areas of wetlands remaining wetlands were recalculated.

7.7.2. Land converted to Wetlands (5.D.2)

a) ***Source/Sink 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 FY2012 were 32 Gg-CO_2; this represents a decrease of 65.0% below the FY1990 value and a decrease of 27.6% below the FY2011 value.

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. Carbon stock changes in soils in wetlands (flooded land) converted from land use other than forest land were not estimated due to lack of data. Therefore, the carbon stock changes in the carbon pool were reported as "NE".

b） ***Methodological Issues***

1） Carbon stock change in Living biomass in "Land converted to Wetlands"

- ***Estimation Method***

The Tier 2 method was applied for the land converted to wetlands (flooded land). The equations are given in section 7.5.2.b)1).

- ***Parameters***

  - ***Biomass stock in each Land-Use Category***

The values shown in Table 7-7 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***

0.5 [t-C/t-d.m.] (*GPG-LULUCF*, default value)

- ***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 7.5.2.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 5.D SECTORAL BACKGROUND

DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Wetlands" is not the annually converted area in FY2012 but the sum of annually converted areas during the past 20 years.

Table 7-40 Area of land annually converted to wetlands (single year)

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Wetlands	kha	0.43	1.72	2.04	0.07	0.14	0.36	0.27	0.23	0.14
Forest land converted to Wetlands	kha	0.31	1.24	1.48	0.05	0.10	0.26	0.19	0.17	0.10
Cropland converted to Wetlands	kha	0.02	0.10	0.11	0.004	0.008	0.02	0.01	0.01	0.01
Rice field	kha	0.01	0.02	0.01	0.001	0.001	0.002	0.001	0.001	0.001
Upland field	kha	0.01	0.05	0.08	0.0023	0.005	0.013	0.01	0.01	0.01
Orchard	kha	0.005	0.018	0.023	0.0007	0.0015	0.0036	0.003	0.002	0.001
Wetlands converted to Wetlands	kha	0.007	0.029	0.042	0.0013	0.003	0.007	0.005	0.005	0.003
Settlements converted to Wetlands	kha	0.002	0.006	0.007	0.0002	0.0005	0.0013	0.001	0.001	0.001
Other land converted to Wetlands	kha	0.09	0.34	0.41	0.01	0.03	0.07	0.05	0.05	0.03

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 7.5.2.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 7-8 and 7-9. 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 7-41 below.

Table 7-41 Area of land converted to wetlands within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Wetlands	kha	28.5	24.7	27.0	21.3	19.1	19.0	18.8	18.7	17.6
Forest land converted to Wetlands	kha	20.6	17.9	19.6	15.4	13.8	13.7	13.6	13.5	12.7
Cropland converted to Wetlands	kha	1.8	1.5	1.5	1.2	1.0	1.0	1.0	1.0	0.9
Rice field	kha	0.7	0.5	0.4	0.2	0.2	0.2	0.2	0.2	0.1
Upland field	kha	0.8	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.6
Orchard	kha	0.3	0.3	0.3	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	0.3
Settlements converted to Wetlands	kha	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	3.8	3.8	3.8	3.7	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 *GPG-LULUCF*. The uncertainty was estimated as 29% of the total emissions from the land converted to wetlands. More detailed information on the uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be reported in future submissions after investigation is completed.

● ***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 7.5.2.b)1), time-series consistency for this subcategory is basically ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

● ***Areas of forest land converted to wetlands***

Areas of forest land converted to wetlands were recalculated because areas of deforestation (D areas) under Article 3, paragraph 3, of the Kyoto Protocol were recalculated. For further information on recalculation of D areas, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

● ***Carbon Stock Changes in living biomass in Forest land converted to Wetlands***

The estimation method on living biomass accumulations in forest land before conversion was revised; hence, the carbon stock changes in living biomass in forest land converted to wetlands were recalculated. For further information on revision of the estimation method on the living biomass accumulations in forest land before conversion, see section 7.5.2.e) in this chapter.

● ***Carbon stock changes in living biomass in cropland converted to wetlands***

Carbon stock changes in living biomass in orchard converted to wetlands were recalculated because of revision of the incorrect unit of a parameter on biomass stock in orchard before conversion.

f） ***Source-/Sink-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.

7.8. Settlements (5.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 FY2012, Japan's settlement area was about 3.78 million ha, equivalent to about 10.0% of the national land. The net emissions by this category in FY2012 were 508 Gg-CO_2. This represents a decrease of 90.1% below the FY1990 value and an increase of 225.4% over the FY2011 value.

In this section, settlements are divided into two subcategories, "Settlements remaining Settlements (5.E.1.)" and "Land converted to Settlements (5.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.

With respect to activity data, the Tier 1a and Tier 1b of the *GPG-LULUCF* assume that removals derived from biomass growth are equal to emissions derived from biomass loss where the average tree age in a green area is older than 20 years. Therefore, carbon stock changes in urban green areas older than 20 years after establishment are regarded as zero and not estimated. Moreover, 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 20 years after establishment),
- Special Greenery Conservation Zones, which are within 20 years after designation.

Table 7-42 Emissions and removals in settlements resulting from carbon stock changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.E. Settlements	Total	Gg-CO_2	5,115.7	3,376.8	1,279.8	314.9	578.7	766.6	1,292.3	156.2	508.3
		Living Biomass	Gg-CO_2	3,460.7	2,181.7	653.5	-34.1	247.1	322.0	670.9	-98.7	216.8
		Dead Wood	Gg-CO_2	1,118.7	793.5	413.2	249.6	251.7	335.5	454.6	212.8	245.5
		Litter	Gg-CO_2	523.7	367.6	185.0	106.4	108.6	149.8	208.5	92.0	108.5
		Soil	Gg-CO_2	12.6	34.0	28.2	-7.0	-28.7	-40.8	-41.7	-49.9	-62.5
	5.E.1. Settlements remaining Settlements	Total	Gg-CO_2	-960.8	-1,034.7	-1,074.5	-1,117.6	-1,068.1	-1,060.7	-1,015.2	-990.0	-968.6
		Living Biomass	Gg-CO_2	-763.7	-826.1	-860.0	-895.6	-853.0	-848.4	-810.8	-791.1	-773.5
		Dead Wood	Gg-CO_2	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE	IE,NE
		Litter	Gg-CO_2	-9.8	-10.4	-10.7	-11.0	-10.7	-10.5	-10.1	-9.9	-9.7
		Soil	Gg-CO_2	-187.3	-198.3	-203.8	-210.9	-204.4	-201.8	-194.2	-189.0	-185.4
	5.E.2. Land converted to Settlements	Total	Gg-CO_2	6,076.5	4,411.6	2,354.3	1,432.5	1,646.8	1,827.3	2,307.4	1,146.2	1,476.9
		Living Biomass	Gg-CO_2	4,224.4	3,007.8	1,513.5	861.6	1,100.1	1,170.4	1,481.7	692.4	990.4
		Dead Wood	Gg-CO_2	1,118.7	793.5	413.2	249.6	251.7	335.5	454.6	212.8	245.5
		Litter	Gg-CO_2	533.5	377.9	195.6	117.4	119.3	160.4	218.7	101.9	118.2
		Soil	Gg-CO_2	199.8	232.3	232.1	203.9	175.7	161.0	152.4	139.1	122.9

7.8.1. Settlements remaining Settlements (5.E.1)

a） ***Source/Sink 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 3, 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 FY2012 was 969 Gg-CO_2; this represents an increase of 0.8% over the FY1990 value and a decrease of 2.2% below the FY2011 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 1a method is used for special greenery conservation zones that are communal green areas, and Tier 1b is used for urban green facilities.

➢ ***Tier 1a: 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 *GPG-LULUCF*

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]

[8] The “Special Greenery Conservation Zones” are not included in Revegetation because they do not meet its definition.

➢ ***Tier 1b: 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 *GPG-LULUCF*
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 1a: 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 *GPG-LULUCF* (p. 3.297) is taken for the annual rate of living biomass growth of trees per crown cover area in special greenery conservation zones.

➢ ***Tier 1b: 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 7-43 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 *GPG-LULUCF* (p. 3.297, Table 3A.4.1) 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. 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 MLITT (Matsue et al., 2009) and the average trunk diameter at breast height for each tree species (Parks and Green Spaces Division of the MLITT, 2005), which were determined from the results of surveys in urban parks. For green areas on roads, the distribution ratio of tree species indicated by the surveys in green areas on roads[9] is taken into account.
	Areas other than Hokkaido	(Other than green areas on roads) 0.0105 (Green areas on roads) 0.0108	

[9] The distribution ratio of tree types is taken from the Road Tree Planting Status Survey (The Street tree of Japan VI), which

● ***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 20-year growth in “Special Greenery Conservation Zones” and “Urban Green Facilities” are estimated.

Japan assumes trees less than or equal to 20-year growth as those growing in urban green areas less than or equal to 20 years since establishment or designation. With respect to Tier 1a, tree crown areas in the “Special Greenery Conservation Zones” are applied as activity data. Tier 1b applies the number of tall trees planted in the “Urban Green Facilities” as activity data.

Table 7-44 Areas of settlements remaining settlements within the past 20 years

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Settlements remaining Settlements		kha	2,349.6	2,650.2	2,855.5	3,040.4	3,160.9	3,197.6	3,244.6	3,281.1	3,321.6
	Urban green facilities	kha	64.3	68.1	70.0	72.4	69.1	68.4	65.2	63.4	61.9
	Special greenery conservation zones	kha	1.9	3.6	4.8	5.5	5.6	5.8	5.9	6.1	6.2
	Other	kha	2,283.4	2,578.4	2,780.8	2,962.5	3,086.2	3,123.4	3,173.5	3,211.6	3,253.6

➢ ***Tier 1a: 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 7-45 Areas of special greenery conservation zones younger than or equal to 20 years since notification

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total		kha	1.9	3.6	4.8	5.5	5.6	5.8	5.9	6.1	6.2
	Green space conservation zones	kha	0.6	0.9	1.4	2.0	2.1	2.3	2.4	2.4	2.5
	Suburban green space conservation zones	kha	1.2	2.7	3.4	3.5	3.5	3.5	3.5	3.7	3.7

➢ ***Tier 1b: 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 11.3.2.5.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

covered green areas on roads throughout Japan.

in the table below.

Table 7-46 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 20 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***

A country-specific method is applied for this estimation because no method for carbon stock changes in litter in settlements is provided in the *GPG-LULUCF*. 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 11.4.1.1.d 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***

Country specific methodology to estimate carbon stock changes in soils on settlements is applied since its default methodology (Tier 1) is not provided by *GPG-LULUCF*.

$$\Delta C_{RVSoils} = \sum_i \left(\Delta C_{Mineral,i} - L_{Organic,i}\right)$$
$$\Delta C_{Mineral,i} = A_i \times \Delta C_{Soil,i}$$

$\Delta C_{SSSoils}$: 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 11.4.1.1.d d), carbon stock changes in soils per area of Urban parks and Green areas at port are estimated based on the results of surveys conducted in urban parks which have been established within 20 years (1.20 t-C/ha/yr) (Tonosaki et al., 2013). Thus, this value is applicable to Urban parks and Green areas at port which were established within 20 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 11.4.1.1.d a) of Chapter 11).

c) *Uncertainties and Time-series Consistency*

● ***Uncertainty Assessment***

The default values shown on page 3.297 in the *GPG-LULUCF* were applied to the annual carbon stock changes for trees in urban parks and 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 *GPG-LULUCF* (page 3.298).

Moreover, the uncertainty estimates for living biomass in special greenery conservation zones apply expert judgment according to the decision tree for activity data in the *GPG-LULUCF*. These estimates were determined as 10% for the number of tall trees and existing trees and the areas of existing special greenery conservation zones, 17% for wooded areas, and 20% for forested areas.

Meanwhile, the uncertainty estimates for activity data and the parameters of 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 67% and 48%, respectively.

As a result, the uncertainty estimate was 35% for the entire removal by settlements remaining settlements. The methodology of uncertainty assessment was described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be reported in future submissions after investigation is completed.

● ***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 7.5.2.b)1), time-series consistency for this subcategory is basically ensured.

d) *Source-/Sink-specific QA/QC and Verification*

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e) *Source-/Sink-specific Recalculations*

● ***Area of settlements remaining settlements***

Areas of settlements remaining settlements were calculated by subtracting areas of land converted to settlements from the total area of settlements. In this submission, areas of forest land converted to cropland were recalculated because D areas were recalculated. As a result of this recalculation, areas of land converted to settlements were also recalculated, and areas of settlements remaining settlements were recalculated, accordingly. For further information on recalculation of D areas, see section 11.4.1.4.

● ***Carbon stock changes in living biomass, litter and soils in settlements remaining settlements***

The areas of settlements remaining settlements, which were activity data for carbon stock changes in living biomass, litter and soils in settlements remaining settlements, were recalculated as mentioned above. Accordingly, the carbon stock changes in living biomass, litter and soils in settlements remaining settlements were recalculated.

f） ***Source-/Sink-specific Planned Improvements***

- ***Growth Rate of Living Biomass per Unit of Greening Area in "Special Greenery Conservation Zones"***

The default values in the *GPG-LULUCF* 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 present estimation method assumes settlement areas as "roads" and "human habitats" in the land-use categorization. However, the validity of the assumption is under re-examination.

7.8.2. Land converted to Settlements (5.E.2)

a） ***Source/Sink Category Description***

Land conversion to settlements results in carbon stock changes in the living biomass, dead organic matter (dead wood and litter) and soil in the land areas subject to the conversion. 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 FY2012 were 1,477 Gg-CO_2; this represents a decrease of 75.7% below the FY1990 value and an increase of 28.9% over the FY2011 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 3.6.2 in the *GPG-LULUCF* (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 1b method in section 3A.4.1.1.1 in the *GPG-LULUCF*.

$$\Delta C_{LSLB} = \sum_{I} \{A_I \times (CR_a - CR_{b,I}) \times CF\} + \sum_{i} (\Delta C_{LS(UG)Gi} - \Delta C_{LS(UG)Li})$$
$$\Delta C_{LS(UG)G} = \Delta B_{LS(UG)G}$$
$$\Delta B_{LS(UG)G} = \sum_{j} NT_j \times C_{Ratej}$$

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 20 years old, therefore, the loss is assumed as "0" (zero) in accordance with the *GPG-LULUCF*
$\Delta B_{LS(UG)G}$: 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 7-7a and 7-7b show the living biomass stocks before and after conversion. Carbon stock losses due to loss of living biomass are assumed as "0" (zero) in accordance with the *GPG-LULUCF*, because trees subject to estimation are all younger than or equal to 20 years old. Table 7-43 shows the annual living biomass growth of trees in land converted to urban green areas.

➢ ***Carbon fraction of dry matter***

0.5 (t-C/t-d.m.) (default value, *GPG-LULUCF*)

● ***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 "NO".

It should be noted that the area presented in the CRF "Table 5.E SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Settlements" is not the annually converted area in FY2012 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 7.5.2.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"), the areas of land converted to factories, roads, housing, and forest roads are used.

Table 7-47 Area of land converted to settlements (single year)

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Settlements	kha	44.8	37.0	24.2	15.1	17.0	15.6	16.7	11.3	12.0
Forest land converted to Settlements	kha	20.2	14.3	7.5	4.5	4.6	6.1	8.3	3.9	4.5
Cropland converted to Settlements	kha	21.4	19.5	14.5	9.2	10.9	8.2	7.2	6.3	6.4
Rice field converted to Settlements	kha	13.0	12.1	9.5	6.0	7.1	5.0	4.1	3.5	3.9
Upland field converted to Settlements	kha	6.1	5.6	3.8	2.5	3.0	2.5	2.4	2.2	2.0
Orchard converted to Settlements	kha	2.3	1.8	1.1	0.7	0.8	0.7	0.6	0.6	0.5
Grassland converted to Settlements	kha	3.2	3.1	2.2	1.4	1.6	1.4	1.3	1.2	1.1
Wetlands converted to Settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to settlements	kha	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 11.3.2.5.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 *GPG-LULUCF*. 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 *GPG-LULUCF*. 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 *GPG-LULUCF*. 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.

$$\Delta C_{FS} = \sum_i \{(C_{after,i} - C_{before,i}) \times A\}$$

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""***

$$\Delta C_{LSLit} = \sum_{I,i} \{A_i \times (C_{AfterLit,i} - C_{BeforeLit,I}) + A_i \times Lit_i\}$$

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 7-8 and 7-9. 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 7-48 below.

Table 7-48 Area of land converted to settlements within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Settlements	kha	869.4	778.8	738.5	657.6	592.1	562.4	534.4	496.9	456.4
Forest land converted to Settlements	kha	289.5	312.6	306.3	268.4	225.7	208.4	196.5	177.0	155.7
Cropland converted to Settlements	kha	520.6	409.1	376.8	338.8	318.8	307.8	293.7	278.0	261.3
Rice field converted to Settlements	kha	320.9	252.1	236.6	215.2	204.6	197.6	188.7	178.9	168.3
Upland field converted to Settlements	kha	137.2	110.5	101.8	91.9	86.1	83.4	79.8	75.7	71.3
Orchard converted to Settlements	kha	62.4	46.5	38.5	31.6	28.1	26.8	25.2	23.4	21.7
Grassland converted to Settlements	kha	59.3	57.2	55.4	50.5	47.6	46.1	44.2	41.9	39.4
Wetlands converted to Settlements	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Other land converted to settlements	kha	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 11.4.1.1.d 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***

Country specific methodology to estimate carbon stock changes in soils on settlements is applied since its default methodology (Tier 1) is not provided by *GPG-LULUCF*.

$$\Delta C_{LSSoils\_all} = \Delta C_{FSSoils} + \Delta C_{LSSoils}$$

$\Delta C_{LSSoils\_all}$: 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 7-10 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 7-48 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 11.4.1.1.d 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 *GPG-LULUCF*. The uncertainty estimate was 31% for the entire emission from land converted to settlements. The methodology used in the uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be presented in future submissions after investigation is completed.

- ***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 7.5.2.b)1), time-series consistency for this subcategory is basically ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

- ***Areas of forest land converted to settlements***

Areas of forest land converted to settlements were recalculated because areas of deforestation (D areas) under Article 3, paragraph 3, of the Kyoto Protocol were recalculated. For further information on recalculation of D areas, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

- ***Carbon stock changes in living biomass in forest land converted to settlements***

The estimation method on living biomass accumulations in forest land before conversion was revised; hence, the carbon stock changes in living biomass in forest land converted to settlements were recalculated. For further information on revision of the estimation method on the living biomass accumulations in forest land before conversion, see section 7.5.2.e) in this chapter.

- ***Carbon stock changes in living biomass in cropland converted to settlements***

Carbon stock changes in living biomass in orchard converted to settlements were recalculated because of revision of the incorrect unit of a parameter on biomass stock in orchard before conversion.

- ***Carbon stock changes in land converted to green areas by greenery promoting systems for private green space***

All green areas by greenery promoting systems for private green space are located in settlements remaining settlements. However, by the previous submission, areas of greenery promoting systems for private green space in land converted to settlements were estimated by means of ratios of land conversion in the national areas, and carbon stock changes in the areas were reported in land converted to green areas by greenery promoting systems for private green space. Therefore, reporting all carbon stock changes in green areas by greenery promoting systems for private green space was corrected to settlements remaining settlements.

f） ***Source-/Sink-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.

7.9. Other land (5.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 *GPG-LULUCF* indicates bare land, rock, ice, and unmanaged land areas. In FY2012, Japan's other land area was about 2.83 million ha, which is equivalent to about 7.5% of the national land. The classification of other land is shown in Table 7-49 below[10].

Table 7-49 Land included in the other land category

Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Other land		kha	2,381.0	2,511.0	2,556.0	2,592.0	2,647.0	2,670.0	2,671.0	2,712.0	2,712.0
	Defense Facility Site	kha	139.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0	140.0
	Cultivation Abandonment Area	kha	216.8	244.3	342.8	385.8	391.9	393.9	396.0	396.0	396.0
	Coast	kha	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0	46.0
	Northern Territories	kha	503.6	503.6	503.6	503.6	503.6	503.6	503.6	503.6	503.6
	Other	kha	1,475.6	1,577.1	1,523.6	1,516.6	1,565.5	1,586.4	1,585.4	1,626.4	1,626.4

The emissions from this category in FY2012 were 289 Gg-CO_2; this represents a decrease of 85.2% below the FY1990 value and a decrease of 2.2% below the FY2011 value.

This section divides other land into two subcategories, "Other land remaining Other land (5.F.1.)" and "Land converted to Other land (5.F.2.)", and describes them separately in the following subsections.

Table 7-50 Emissions and removals resulting from carbon stock changes in other land

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	5.F. Other land	Total	Gg-CO_2	1,950.1	1,837.1	1,350.5	1,000.3	328.5	319.1	341.4	295.5	289.0
		Living Biomass	Gg-CO_2	1,443.6	1,402.2	1,013.2	720.1	237.0	240.3	238.4	231.1	214.5
		Dead Wood	Gg-CO_2	277.0	227.9	165.3	136.5	16.3	11.6	30.9	8.0	17.2
		Litter	Gg-CO_2	133.0	109.4	79.4	65.5	7.8	5.6	15.0	3.9	8.4
		Soil	Gg-CO_2	96.5	97.7	92.7	78.2	67.4	61.7	57.2	52.6	48.9
	5.F.1. Other land remaining Other land	Total	Gg-CO_2									
		Living Biomass	Gg-CO_2									
		Dead Wood	Gg-CO_2									
		Litter	Gg-CO_2									
		Soil	Gg-CO_2									
	5.F.2. Land converted to Other land	Total	Gg-CO_2	1,950.1	1,837.1	1,350.5	1,000.3	328.5	319.1	341.4	295.5	289.0
		Living Biomass	Gg-CO_2	1,443.6	1,402.2	1,013.2	720.1	237.0	240.3	238.4	231.1	214.5
		Dead Wood	Gg-CO_2	277.0	227.9	165.3	136.5	16.3	11.6	30.9	8.0	17.2
		Litter	Gg-CO_2	133.0	109.4	79.4	65.5	7.8	5.6	15.0	3.9	8.4
		Soil	Gg-CO_2	96.5	97.7	92.7	78.2	67.4	61.7	57.2	52.6	48.9

7.9.1. Other land remaining Other land (5.F.1)

a） ***Source/Sink 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, cultivation abandonment areas, coasts, and northern territories. However, carbon stock changes in this subcategory are not considered in accordance with the *GPG-LULUCF*.

[10] These land areas are based on the following statistics: "*Defense of Japan*" by the Ministry of Defense for "Defense Facility Site", "*World Census of Agriculture and Forestry*" for "Cultivation Abandonment Area", "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 7-51 Areas of other land remaining other land within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Other land remaining Other land	kha	2,067.8	2,216.7	2,274.7	2,199.0	2,273.6	2,327.6	2,321.6	2,378.5	2,413.1

b） ***Source-/Sink-specific Recalculations***

● ***Areas of other land remaining other land***

Statistical data on the total national land area was changed from the *Land Use Status Survey* to the *Statistical Reports on the Land Area by Prefectures and Municipalities in Japan*. The reason of this change is that the *Statistical Reports* are the data source of the *Land Use Status Survey* and provide more detailed data than the *Land Use Status Survey*. As a result of this change, the areas of other land remaining other land, which are determined by subtracting the summed areas of the other five land-use categories from the total national land area, were recalculated.

c） ***Source-/Sink-specific Planned Improvements***

● ***Method of Defining Land Areas***

7.5% of the nation’s land is categorized as other land remaining other land, but the validity of the categorization is presently under examination in a cross-cutting manner through the LULUCF sector. In addition, areas of abandoned cultivated areas presently include those of other land remaining other land. Japan is examining whether this allocation of the areas of abandoned cultivated areas to other land remaining other land is appropriate, or the areas of abandoned cultivated areas should be reallocated to another land-use category.

● ***Carbon Stock Changes in Living Biomass in “Other land remaining Other land”***

The carbon stock changes in the living biomass in other land remaining other land are assumed to be zero, but this assumption may differ from the actual situation. Therefore, the land-use types in the other land category will be investigated, and the validity of the assumption will be re-examined. If there are some land-use types that contain living biomass, reclassification of land-use categories will be considered.

7.9.2. Land converted to Other land (5.F.2)

a） ***Source/Sink 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 FY2012 were 289 Gg-CO_2. This represents a decrease of 85.2% below the FY1990 value and a decrease of 2.2% below the FY2011 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 7.5.2.b)2) and 7.6.2.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 7.5.2.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 7-7a and7-7b 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***

0.5 (t-C/t-d.m.) (*GPG-LULUCF*, default value)

● ***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. Therefore, they were reported as “NO.”

It should be noted that the area presented in the CRF “Table 5.F SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Other land” is not the annually converted area in FY2012 but the sum of annually converted areas during the past 20 years.

➢ ***Conversion from Forest Land***

See section 7.5.2.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 Moving and Conversion of Cropland*) are used.

Table 7-52 Area of land converted to other land (single year)

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Other land	kha	24.2	30.3	24.7	18.2	11.1	11.4	9.4	25.7	9.8
Forest land converted to Other land	kha	5.0	4.1	3.0	2.5	0.3	0.2	0.6	0.1	0.3
Cropland converted to Other land	kha	15.4	20.3	17.1	13.2	8.8	8.8	7.2	23.0	7.7
Rice field	kha	5.0	5.8	6.1	7.2	4.0	2.9	3.1	16.9	3.4
Upland field	kha	7.6	10.9	8.4	4.7	3.8	4.6	3.2	4.8	3.4
Orchard	kha	2.8	3.6	2.5	1.3	1.0	1.2	0.8	1.3	0.9
Grassland converted to Other land	kha	3.9	5.9	4.6	2.6	2.0	2.4	1.7	2.5	1.8
Wetlands converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Settlements converted to Other land	kha	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 7.5.2.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 7-8 and 7-9. 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 7-53 Area of land converted to other land within the past 20 years

Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Land converted to Other land	kha	600.2	523.0	497.3	495.3	465.7	445.2	430.4	431.4	417.8
Forest land converted to Other land	kha	103.8	105.1	99.7	84.1	71.0	65.4	61.0	55.5	51.3
Cropland converted to Other land	kha	419.6	338.1	316.5	324.8	311.2	299.7	291.5	299.4	292.1
Rice field	kha	181.2	120.3	105.0	108.4	106.3	105.1	103.2	115.4	113.9
Upland field	kha	164.2	153.7	154.8	161.8	154.9	147.9	143.5	140.7	136.7
Orchard	kha	74.2	64.1	56.6	54.6	50.0	46.8	44.8	43.3	41.5
Grassland converted to Other land	kha	76.9	79.9	81.2	86.4	83.5	80.1	77.9	76.5	74.4
Wetlands converted to Other land	kha	IE	IE	IE	IE	IE	IE	IE	IE	IE
Settlements converted to Other land	kha	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 7.5.2.b)3.

- ***Parameters***

The parameters described in table 7-10 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 7-53.

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 *GPG-LULUCF*. The uncertainty was estimated as 40% for the entire emission from the land converted to other land. More detailed information on the uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be given in future submissions after investigation is completed.

● ***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 7.5.2.b)1), the time-series consistency for this subcategory is basically ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

● ***Areas of forest land converted to other land***

Areas of forest land converted to other land were recalculated because areas of deforestation (D areas) under Article 3, paragraph 3, of the Kyoto Protocol were recalculated. For further information on recalculation of D areas, see "*Revisions of AR and D areas and recalculation of FM areas*" in section 11.4.1.4. in chapter 11 in this NIR.

● ***Carbon Stock Changes in Living Biomass in Forest land converted to Other land***

The estimation method on living biomass accumulations in forest land before conversion was revised; hence, the carbon stock changes in living biomass in forest land converted to other land were recalculated. For further information on revision of the estimation method on the living biomass accumulations in forest land before conversion, see section 7.5.2.e) in this chapter.

● ***Carbon stock changes in living biomass in cropland converted to other land***

Carbon stock changes in living biomass in orchard converted to other land were recalculated because of revision of the incorrect unit of a parameter on biomass stock in orchard before conversion.

f） ***Source-/Sink-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.

7.10. Direct N_2O emissions from N fertilization (5. (I))

a) *Source/Sink Category Description*

This category deals with direct N_2O emissions from N fertilization in forest land. The emissions by this subcategory in FY2012 were 0.55Gg-CO_2. This represents a decrease of 36.7% below the FY1990 value.

Table 7-54 Direct N_2O emissions from N fertilization

Gas	Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
N_2O	Total	Gg-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
		Gg-CO_2 eq.	0.9	0.7	0.7	0.7	0.5	0.5	0.6	0.5	0.5
	Forest land	Gg-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Forest land remaining Forest land	Gg-N_2O	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	Land converted to Forest land	Gg-N_2O	IE	IE	IE	IE	IE	IE	IE	IE	IE
	Other	Gg-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) *Methodological Issues*

- ***Estimation Method***

The direct N_2O emissions from N fertilization were estimated by applying Tier 1 estimation method described in section 3.2.1.4.1.1 in *GPG-LULUCF*. The estimation equation is as follows:

$$N_2O\ direct\text{-}N_{fertilizer} = (F_{SN} + F_{ON}) \times EF_1$$

$N_2O\ direct\text{-}N_{fertiliser}$: Direct N_2O emissions from Nfertilization to soils in forest land [kg-N_2O-N]

F_{SN} : Annual amount of nitrogen contained in synthetic fertilizer applied to soils in forest land [Gg-N]

F_{ON} : Annual amount of nitrogen contained in organic fertilizer applied to soils in forest land [Gg-N]

EF_1 : N_2O emission factor of application of synthetic fertilizer to soils in forest land [kg-N_2O-N/kg-N input]

- ***Parameters***

➢ ***Emission factor***

The emission factor (0.62% [kg-N_2O-N/kg-N[11]]), 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 6.5.1.1.b) in chapter 6 in this NIR.

- ***Activity Data***

Results of surveys from 2006 to 2008 on fertilizer application to soils in forest land are base data on the activity data. 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 amount of synthetic fertilizer

[11] Akiyama et al., Direct N2O emissions and estimate of N2O emission factors from Japanese agricultural soils. (2006)

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, which was described in section 6.5.1.1.b) in chapter 6, by the average percentage of synthetic fertilizer application to soils in forest land in the period from 2006 to 2008. The average percentage is 0.0047% of the total amount of synthetic fertilizer application.

c） ***Uncertainties and Time-series Consistency***

- ***Uncertainty Assessment***

The uncertainty estimates of N_2O emissions from N fertilization were 139% by applying the same value as the estimation of the N_2O emissions from N fertilization in agriculture sector. The methodology of uncertainty assessment was described in Annex 7.

- ***Time-series Consistency***

Time-series consistency for this category is ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

- ***Direct N_2O emissions from N fertilization to soils in forest land***

Amount of N fertilization to forest land was separated from agriculture sector, and d***i***rect N_2O emissions from N fertilization in forest land were reported in LULUCF sector. Hence, reporting this subcategory was changed from “IE” to N2O emission estimates.

f） ***Source-/Sink-specific Planned Improvements***

None.

7.11. N_2O emissions from drainage of soils (5.(II))

a） ***Source/Sink Category Description***

Regarding the N_2O emissions from soil drainage activities in forest land and wetlands, experts noted that the N_2O emissions did not occur, because soil drainage activities were not carried out in general in Japan. Based on this comment, this category is reported as “NO”.

7.12. N_2O emissions from disturbance associated with land-use conversion to Cropland (5.(III))

a） ***Source/Sink Category Description***

This category deals with N_2O emissions from disturbance associated with land-use conversion to cropland. The emissions by this subcategory in FY2012 were 3.98 Gg-CO_2. This represents a decrease of 94.3% below the FY1990 value and a decrease of 19.0% below the FY2012 value.

Table 7-55 N_2O emissions from disturbance associated with land-use conversion to cropland

Gas	Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
N_2O	Total	Gg-N_2O	0.23	0.16	0.09	0.04	0.03	0.02	0.02	0.02	0.01
		Gg-CO_2 eq.	70.28	49.01	28.91	13.19	8.90	7.22	5.66	4.92	3.98
	Cropland	Gg-N_2O	0.23	0.16	0.09	0.04	0.03	0.02	0.02	0.02	0.01
	Forest land converted to Cropland	Gg-N_2O	0.21	0.16	0.09	0.04	0.03	0.02	0.02	0.02	0.01
	Grassland converted to Cropland	Gg-N_2O	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Wetlands converted to Cropland	Gg-N_2O	0.0143	0.0027	0.0006	0.0003	0.0003	0.0003	0.0002	0.0002	0.0002
	Other land converted to Cropland	Gg-N_2O	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE	NA,NE
	Other	Gg-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA

b) *Methodological Issues*

● *Estimation Method*

According to the *GPG-LULUCF*, the Tier 1 method is used.

$$N_2O-N_{conv} = N_2O_{net-\min} - N$$

$$N_2O_{net-\min} - N = EF \times N_{net-\min}$$

$$N_{net-\min} = C_{released} \times 1/CN_{ratio}$$

- N_2O - N_{conv} : N_2O emissions due to land-use conversion to cropland [kgN_2O-N]
- $N_2O_{net\text{-}min}$ - N : N_2O emissions due to land-use conversion to cropland [kgN_2O-N/ha/yr]
- $N_{net\text{-}min}$: annual N emissions from soil disturbance associated with mineralization of soil organic matter [kgN/ha/yr]
- EF : emission factor
- CN_{ratio} : Carbon Nitrogen ratio of the biomass
- $C_{released}$: soil carbon stock that has been mineralized within the past 20 years

● *Parameters*

➢ *CN ratio for soils*

11.3 (Country specific data (Ministry of the Environment, 2006))

➢ *N-N_2O emission factor for soils*

0.0125 kg-N_2O-N/kg-N (default value stated in the *GPG-LULUCF*, Page 3.94)

● *Activity Data*

Areas of land converted to cropland and carbon emissions from soils due to this conversion are used. The areas are the same as those shown in Table 7-30.

c) *Uncertainties and Time-series Consistency*

● *Uncertainty Assessment*

The uncertainties of parameters were individually assessed on the basis of field studies, expert judgment, or default values described in the *GPG-LULUCF*, and the uncertainty estimates for the carbon emissions from soil in land converted to cropland were applied to the activity data of this category. As a result, the uncertainty estimates of N_2O emissions from disturbance associated with land-use conversion to cropland were 82%. The methodology of uncertainty assessment was described in Annex 7.

● *Time-series Consistency*

Time-series consistency for this category is ensured.

d) *Source-/Sink-specific QA/QC and Verification*

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the

GPG-LULUCF. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

● ***Areas of forest land converted to cropland***

The areas of forest land converted to cropland were recalculated due to recalculation of D areas. As a result, the N2O emissions from this category were recalculated. For further information on the recalculation of D areas, see section 11.4.1.4.

f） ***Source-/Sink-specific Planned Improvements***

● ***Estimation Method of the "Area converted from Forest Land to Cropland" and "from Grassland to Cropland"***

The methods used to obtain data on the area of forest land converted to cropland and grassland converted to cropland need to be improved as mentioned in section 7.5.2.f). Therefore, the validity of the estimates is being reviewed, and the estimation method is being reexamined.

● ***Method of Obtaining Data of the "Area converted from Grassland to Cropland"***

Data on the area of land converted from grassland to cropland cannot be obtained from current statistics, so the carbon stock changes in the areas have not been estimated. Therefore, the methods used to obtain data need to be investigated for the following areas:

・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.

● ***N_2O emissions from grassland converted to cropland***

See section 7.5.2.f).

● ***Estimation Method of Carbon Stock Changes in Other Land converted to Cropland***

The methods for carbon stock changes in other land converted to cropland will be examined when new information on the carbon stock changes is obtained.

7.13. CO_2 emissions from agricultural lime application (5.(IV))

a） ***Source/Sink Category Description***

This category deals with CO_2 emissions from agricultural lime application. The emissions from this category in FY2012 were 247 Gg-CO_2. This represents a decrease of 55.2% below the FY1990 value. One of the reasons for the decline compared to FY1990 is that the amount of calcium carbonate fertilizer applied in Japan has decreased because the chemical nature of soils was progressively improved by soil amendment.

Table 7-56 CO_2 emissions from agricultural lime application

Gas	Category			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	Total			Gg-CO_2	550.2	303.5	332.9	231.3	305.7	270.2	242.9	246.8	246.8
		Cropland		Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
		Grassland		Gg-CO_2	IE	IE	IE	IE	IE	IE	IE	IE	IE
		Other		Gg-CO_2	550.2	303.5	332.9	231.3	305.7	270.2	242.9	246.8	246.8
			Limestone	Gg-CO_2	549.9	303.0	332.4	230.7	304.1	269.6	241.9	245.6	245.6
			Dolomite	Gg-CO_2	0.3	0.5	0.5	0.6	1.7	0.6	1.0	1.1	1.1

b) *Methodological Issues*

● ***Estimation Method***

The Tier 1 method is used in accordance with the *GPG-LULUCF* (page 3.80).

$$\Delta C_{CCLime} = \left(M_{Limestone} \times EF_{Limestone} + M_{Dolomite} \times EF_{Dolomite}\right) \times 44/12$$

ΔC_{CCLime} : 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 ($CaCO_3$)***

0.120 [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 Ministry of Agriculture, Forestry and Fisheries of Japan. 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 was classified as calcic limestone ($CaCO_3$), and all of the “Magnesium carbonate fertilizer” and 74% of “Mixed magnesium fertilizer” as dolomite ($CaMg(CO_3)_2$).

c) *Uncertainties and Time-series Consistency*

● ***Uncertainty Assessment***

The uncertainty for this category was assessed based on the uncertainty of the emission factor (see *2006 Guidelines*, p.11.27) and that of the statistics that provided the activity data. Consequently, the uncertainty of CO_2 emissions from this category was assessed and estimated as 51%. More detailed information on the uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for each parameter in this category will be given in future submissions after investigation is completed.

● ***Time-series Consistency***

Time-series consistency for this category is ensured.

d） ***Source-/Sink-specific QA/QC and Verification***

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. More detailed information on the QA/QC activity procedures is described in section 6.1 of Annex 6.

e） ***Source-/Sink-specific Recalculations***

Amount of lime application in FY2010 and FY2011

Activity data on FY2010 and FY2011 were updated; hence, the emissions in these two years were recalculated.

f） ***Source-/Sink-specific Planned Improvements***

None.

7.14. Biomass burning (5.(V))

a） ***Source/Sink Category Description***

This category deals with emissions of CH_4, CO, N_2O and NOx from biomass burning resulting from forest fires. The emissions resulting from wildfires in forest land remaining forest land and land converted to forest land are reported in a lump in the cell for wildfires in forest land remaining forest land in the CRF tables, because the data in the statistics for forest fires include the wildfires occurred in both of the categories. Moreover, controlled burning activities in forests 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”.

Controlled burning resulting from land conversion from land-use categories other than forest land to forest land is not carried out in Japan, either, because of stringent restrictions imposed under the “Waste Management and Public Cleansing Act” and the “Fire Service Act”. Hence, emissions derived from controlled burning resulting from land conversion from land-use categories other than forest land to forest land do not occur, either, and are also reported as “NO”.

CH_4, CO, N_2O and NOx emissions from controlled burning in cropland are reported as “NE” because they are not estimated due to lack of data. CH_4, CO, N_2O and NOx emissions from wildfires in cropland are reported as “NO”. 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, CO, N_2O and NOx emissions from wildfires in land other than forest land and cropland are reported as “NE” because information on wildfires is not sufficiently collected.

The emissions by this subcategory in FY2012 were 1.75 Gg-CO_2. This represents a decrease of 81.3% below the FY1990 value and a decrease of 70.3% below the FY2011 value. These variations originate mainly from variations in the volume of timber damaged in wildfires in private forests (Table 7-59).

Table 7-57 Non-CO_2 emissions from biomass burning

Gas	Category		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
All	Total		Gg-CO_2 eq.	9.4	9.6	8.6	10.1	23.9	9.5	4.6	5.9	1.8
CH_4	Total		Gg-CH_4	0.4	0.4	0.4	0.4	1.0	0.4	0.2	0.3	0.1
			Gg-CO_2 eq.	8.5	8.7	7.8	9.2	21.7	8.6	4.1	5.4	1.6
		Forest land	Gg-CH_4	0.4	0.4	0.4	0.4	1.0	0.4	0.2	0.3	0.1
		Cropland	Gg-CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Grassland	Gg-CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Wetlands	Gg-CH_4	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Settlements	Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Other land	Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Other	Gg-CH_4	NA	NA	NA	NA	NA	NA	NA	NA	NA
N_2O	Total		Gg-N_2O	0.003	0.003	0.003	0.003	0.007	0.003	0.001	0.002	0.001
			Gg-CO_2 eq.	0.864	0.886	0.790	0.931	2.205	0.874	0.420	0.543	0.162
		Forest land	Gg-N_2O	0.003	0.003	0.003	0.003	0.007	0.003	0.001	0.002	0.001
		Cropland	Gg-N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Grassland	Gg-N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Wetlands	Gg-N_2O	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
		Settlements	Gg-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Other land	Gg-N_2O	NO	NO	NO	NO	NO	NO	NO	NO	NO
		Other	Gg-N_2O	NA	NA	NA	NA	NA	NA	NA	NA	NA

b） *Methodological Issues*

- ***Estimation Method***

For CH_4, CO, N_2O and NOx emissions due to biomass burning, the Tier 1 method is used.

➢ ***Forest land***

(CH_4、CO)

$$bbGHG_f = L_{forestfires} \times ER$$

(N_2O、NOx)

$$bbGHG_f = L_{forestfires} \times ER \times NC_{ratio}$$

$bbGHG_f$: GHG emissions due to forest biomass burning

$L_{forest\ fires}$: Carbon released due to forest fires [tC/yr]

ER : Emission ratio (CO：0.06、CH_4：0.012、N_2O：0.007、NO_x：0.121)

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.
CO: 0.06, CH_4: 0.012, N_2O: 0.007, NOx: 0.121
(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 *GPG-LULUCF*. 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.

$$\Delta C = \Delta C_i + \Delta C_c$$

$L_{forest\ fires}$: 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]

- ***National forest***

$$\Delta C_{fn} = Vf_n \times D_n \times BEF_n \times CF$$

ΔC_{fn} : carbon emissions due to fire in national forests [t-C/yr]
Vf_{fn} : damaged timber volume due to fire in national forests [m^3/yr]
D_n : wood density in national forests [t-d.m./m^3]
BEF_n : biomass expansion factor for national forests
CF : carbon fraction of dry matter [t-C/t-d.m.]

- ***Private forest***

$$\Delta C_{fP} = Vf_p \times D_P \times BEF_P \times CF$$

ΔC_{fp} : carbon emissions due to fire in private forests [t-C/yr]
Vf_p : damaged timber volume due to fire in private forests [m^3/yr]
D_p : wood density in private forests [t-d.m./m^3]
BEF_p : biomass expansion factor for private forests
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 7-58 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

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.

Table 7-59 Damaged timber volume due to wild fire

Category			Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Damaged timber volume due to disturbance in national fore			m^3	3,688.0	1,014.0	1,599.0	359.0	1,901.0	976.0	16,091.0	934.0	360.0
Damaged timber volume due to disturbance in private fores			m^3	63,601.8	68,360.7	60,227.9	72,575.5	170,730.3	67,417.1	15,809.5	41,537.0	12,268.9
	≧5	Actual damaged area	kha	0.29	0.94	0.48	0.35	0.57	0.37	0.07	0.59	0.10
		Damaged timber volume	m^3	47,390.0	58,129.0	54,487.0	59,235.0	119,900.0	55,628.0	12,780.0	40,477.0	11,566.0
	≦4	Actual damaged area	kha	0.27	0.51	0.16	0.27	0.85	0.28	0.06	0.07	0.03
		Damaged timber volume	m^3	16,211.76	10,231.74	5,740.89	13,340.50	50,830.31	11,789.06	3,029.53	1,059.98	702.89

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.

c) *Uncertainties and Time-series Consistency*

- ***Uncertainly Assessment***

The uncertainties for parameters and activity data related to biomass burning were individually assessed on the basis of field studies, expert judgment, or default values described in the *GPG-LULUCF*. As a result, the uncertainty estimates for the emissions resulting from biomass burning were 45% for CH_4 and 108% for N_2O, respectively. The methodology of uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be reported in future submissions after investigation is completed.

- ***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 2012.

d) *Source-/Sink-specific QA/QC and Verification*

QC is implemented in accordance with the Tier 1 approach described in the *GPG (2000)* and the *GPG-LULUCF*. The Tier 1 approach includes procedures for checking parameters and activity data, and for archiving references. The QA/QC activity procedures are described in section 6.1 of Annex 6.

e) *Source-/Sink-specific Recalculations*

None.

f) *Source-/Sink-specific Planned Improvements*

- ***Burning of pruned branches from orchard trees***

Although woody biomass such as pruned branches from orchard trees may partially be burnt, non-CO_2 emissions from this burning are not estimated. When data for the treatment of orchard tree residues become available, the emissions will be estimated and reported in the inventories.

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Chapter 8. Waste (CRF sector 6)

8.1. Overview of Sector

8.1.1. 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 on land (6.A.), wastewater handling (6.B.), waste incineration (6.C.), and other (6.D.)[1] in accordance with treatment processes. Figure 8-1 and Figure 8-2 show the estimation categories of waste/wastewater treatment system and/or waste classification in Japan.

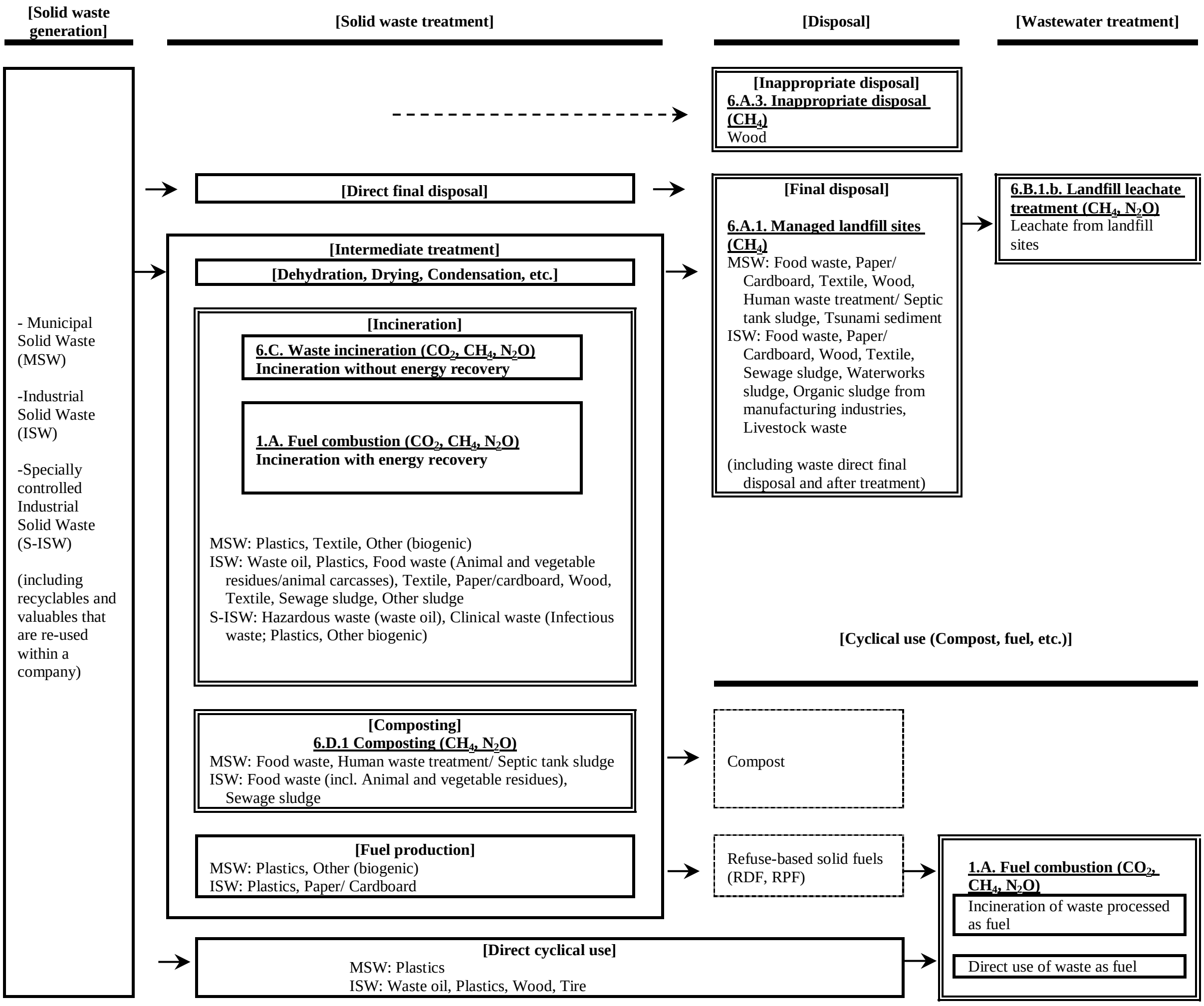

Figure 8-1 Flow chart of solid waste managements and the estimation categories

[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).

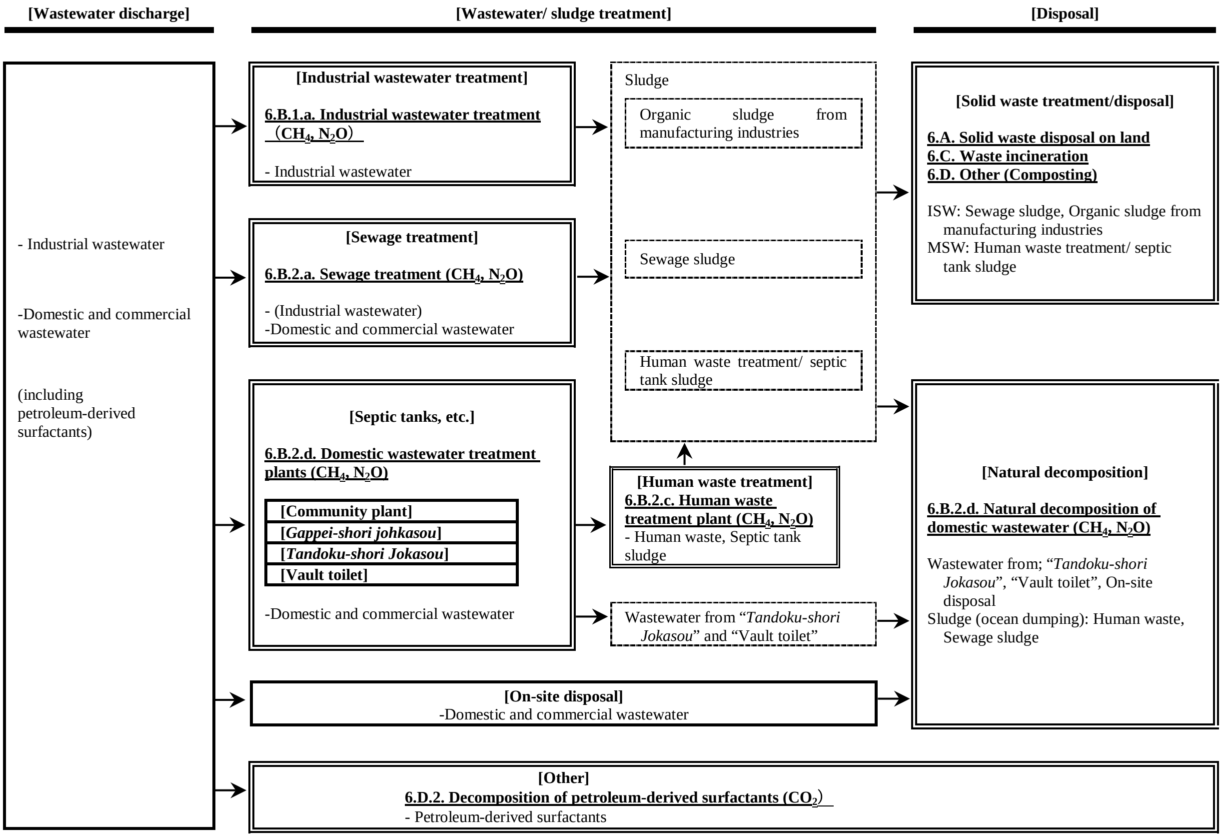

Figure 8-2 Flow chart of wastewater/sludge treatments and the estimation categories

Waste to be covered in this sector is the waste as defined in the Revised 1996 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, is reported in this sector.

8.1.2. Overview of Greenhouse Gas Emissions on Waste Sector

In FY2012, emissions from the Waste sector resulted in 20,029 Gg-CO2 eq. and accounted for 1.5% of Japan's total greenhouse gas emissions (excluding LULUCF). Total emissions had decreased by 22.8% compared to those of FY1990 and decreased by 0.8% compared to those of FY2011. Breakdown of FY2012 emissions of the Waste sector by category shows that the largest contributor to the emissions is Waste Incineration (6.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 68.1% (an decrease by 1.0% from FY1990) followed by the Solid Waste Disposal on Land (6.A.) accounting for 14.6% (a decrease by 61.7% from FY1990), Wastewater Handling (6.B.) accounting for 13.2% (a decrease by 27.9% compared to FY1990), and Other (Waste) (6.D.) accounting for 4.1% (a decrease by 5.8% 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 60%, followed by CH_4 emissions from solid waste disposal on land accounting for 15%, N_2O emissions from waste incineration accounting for 8% (including incineration of waste other than petroleum-derived waste).

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 the Act for Promotion of Use of Recycled Resources. 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 51.1% from FY1990).

8.1.3. 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, provisional data are applied for the activity data of the latest reporting year. Consequently, every year, these provisional data are updated with determined data, and emission estimates are recalculated in the inventory of its next annual submission.

8.2. Solid Waste Disposal on Land (6.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 8-1.

Table 8-1 Categories whose emissions are estimated for solid waste disposal on land (6.A.)

<table>
<tr><th>Category</th><th colspan="4">Waste types estimated</th><th>Treatment type</th></tr>
<tr><td rowspan="15">6.A.1.(8.2.1)</td><td rowspan="6">Municipal solid waste</td><td colspan="3">Food waste</td><td rowspan="5">Anaerobic landfill
and
Semi-aerobic landfill</td></tr>
<tr><td colspan="3">Paper/ Cardboard</td></tr>
<tr><td colspan="3">Wood</td></tr>
<tr><td colspan="3">Textiles (natural fiber) [a]</td></tr>
<tr><td rowspan="2">Sludge</td><td colspan="2">Human waste treatment, Septic tank sludge</td></tr>
<tr><td colspan="2">Tsunami sediment [b]</td><td>Anaerobic landfill [g]</td></tr>
<tr><td rowspan="9">Industrial waste</td><td>Food waste [c]</td><td colspan="2">Animal and vegetable residues/animal carcasses</td><td rowspan="9">Anaerobic landfill
and
Semi-aerobic landfill</td></tr>
<tr><td colspan="3">Paper/ Cardboard</td></tr>
<tr><td colspan="3">Wood</td></tr>
<tr><td colspan="3">Textiles (natural fiber) [a]</td></tr>
<tr><td rowspan="5">Sludge</td><td rowspan="2">Sewage sludge</td><td>Digested sewage sludge [d]</td></tr>
<tr><td>Other sewage sludge</td></tr>
<tr><td colspan="2">Waterworks sludge</td></tr>
<tr><td colspan="2">Organic sludge from manufacturing industries</td></tr>
<tr><td colspan="2">Livestock waste [e]</td></tr>
<tr><td>6.A.3.(8.2.3)</td><td colspan="4">Inappropriate disposal [d]</td><td>Anaerobic landfill</td></tr>
</table>

Note:

a) Only natural fiber textiles are included in the estimation under the assumption that synthetic fiber waste is not biologically decomposed in landfills.

b) 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.

c) Japan's industrial waste classifications of "Animal and vegetable residues" and "Animal carcasses" are aggregated as food waste.

d) "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.

e) 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.

f) Waste inappropriately disposed of containing biodegradable carbon is considered to include wood.

g) Since the condition of tsunami sediment disposed of is not identified, it is conservatively assumed as anaerobic landfill.

Table 8-2 GHG emissions from solid waste disposal on land (6.A.)

Category	Item		Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
6.A.1. Managed Solid Waste Disposal site	Food waste		Gg-CH_4	62.9	60.2	50.3	32.7	21.5	18.6	15.9	13.9	12.3
	Paper/ Cardboad		Gg-CH_4	147.5	136.4	114.5	92.2	78.8	74.5	70.0	65.8	62.1
	Textiles (natural fiber)		Gg-CH_4	9.6	8.6	7.3	6.7	6.0	5.6	5.1	4.7	4.3
	Wood		Gg-CH_4	46.4	50.4	49.8	47.7	45.9	45.2	44.5	43.8	43.1
	Human waste treatment, Septic tank sludge		Gg-CH_4	12.4	9.0	6.5	4.8	3.7	3.4	3.0	2.7	2.4
	Tsunami sediment		Gg-CH_4	NO	NO	NO	NO	NO	NO	NO	NO	0.04
	Sewage sludge	Digested sewage sludge	Gg-CH_4	5.5	5.0	3.8	2.4	1.6	1.4	1.2	1.0	0.9
		Other sewage sludge	Gg-CH_4	27.3	24.9	19.2	11.8	7.9	6.8	5.9	5.1	4.8
	Waterworks sludge		Gg-CH_4	3.4	3.2	2.6	1.8	1.4	1.3	1.2	1.2	1.1
	Organic sludge from industry		Gg-CH_4	47.8	37.6	22.8	13.9	9.7	8.4	7.3	6.6	6.1
	Livestock waste		Gg-CH_4	1.4	1.4	1.3	1.1	1.0	1.0	1.0	1.0	1.0
	Recovery		Gg-CH_4	-0.8	-0.7	-0.7	0.0	-0.3	-0.3	-0.4	-0.4	-0.6
	Total		Gg-CH_4	363.3	335.8	277.4	215.2	177.3	165.9	154.8	145.4	137.4
6.A.3. Other	Inappropriate disposal		Gg-CH_4	0.3	0.8	2.4	2.4	2.1	2.0	2.0	2.0	2.0
Total			Gg-CH_4	363.7	336.7	279.8	217.5	179.4	167.8	156.8	147.4	139.4
			Gg-CO_2 eq	7,637	7,070	5,875	4,568	3,767	3,525	3,292	3,096	2,928

Estimated greenhouse gas emissions from solid waste disposal on land are shown in Table 8-2. In FY2012, greenhouse gas emissions from this source category are 2,928 Gg-CO_2 eq. and accounted for 0.2% of the national total emissions (excluding LULUCF). Emissions from this category decreased by 61.7% 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.

8.2.1. Emissions from Managed Landfill Sites (6.A.1.)

a) *Source/Sink Category Description*

In Japan, part of food waste, paper/cardboard, textiles, wood, and sludge in municipal solid waste (MSW) and industrial waste (ISW) 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 “Emissions from Managed Landfill Sites (6.A.1.)”. Emissions of CO_2 from waste incineration at the managed landfill sites are reported as NO, because waste incineration is not implemented at that site in Japan.

b) *Methodological Issues*

- ***Estimation Method***

The revised FOD method given in the 2006 IPCC Guidelines is applied for its emission estimates since this method assumes a process of delay time from the deposition of waste to the substantial rate of CH4 production. 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 “CH4 emissions from biodegradable waste”, and activity data are defined as “the amount of waste biodegraded within the reporting fiscal year”.

$$E = \left\{ \sum \left(EF_{ij} \times A_{ij} \right) - R \right\} \times \left(1 - OX \right)$$

Where：

E : CH_4 emissions from landfill sites [kg-CH_4]

EF_{ij} : Emission factor for a biodegradable waste i (dry basis) that is damped into a landfill site j without incineration [kg-CH_4/t]

A_{ij} : 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)

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

$$EF_{iCH4} = DOC_i \times DOCF \times MCF \times F \times 1000 \times 16/12$$

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, was 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 #15) and Reference #7 as indicated in Table 8-3.

Table 8-3 Carbon content of waste disposed of in managed landfill sites (dry base)

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) ISW: Substituted the carbon content for the MSW for ISW because its properties are similar to those of MSW (Reference #15)
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” from GPG2000
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 Reference #51, 52, 60, 65)
Other sewage sludge	40.0	GPG2000
Waterworks sludge	6.0	Average values of survey results conducted at 23 water purification plants (Reference #15)
Organic sludge from manufacturing	45.0	Value for papermaking industry was 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” from GPG2000

- ***Fraction of degradable organic carbon dissimilated***

  Fraction of degradable organic carbon dissimilated for the biodegradable waste was set at 50% based on Ito (1992) (Reference #54).

- ***Methane Correction Factor***

  Default values given in the 2006 IPCC Guidelines are used: 1.0 for anaerobic landfill sites and 0.5 for semi-aerobic landfill sites.

- ***Proportions of CH_4 in Generated Gas***

  Default value (50%) given in the Revised 1996 IPCC Guidelines was used.

Table 8-4 Emission factors by type of biodegradable waste and by treatment

Item	Anaerobic landfill [kg-CH_4/t]	Semi-aerobic landfill [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	
Digested sewage sludge	100	50
Other sewage sludge	133	67
Waterworks sludge	20	10
Organic sludge from manufacturing	150	75
Livestock waste	133	67

- ***Activity Data***

Out of the amount of waste landfilled without incineration (dry basis), the amount of waste degraded within the reporting year was 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 ISW are determined by type of waste and landfill site.

The amount of waste landfilled in each fiscal year was 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.

$$W_i(T) = W_i(T-1) \times e^{-k} + w_i(T)$$
$$A_i(T) = W_i(T-1) \times (1 - e^{-k})$$
$$k = \ln(2) / H$$

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
= (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 8-5 shows the annual amount of biodegradable waste landfilled (dry basis) in Japan.

Table 8-5 Annual amount of biodegradable waste disposed of in landfills
(Total amount of anaerobic and semi-aerobic landfilling)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Food waste	kt / year (dry)	505	493	311	135	79	66	65	68	67
Paper/ Cardboad	kt / year (dry)	1,213	949	766	534	387	312	315	291	267
Textiles (natural fiber)	kt / year (dry)	62	56	44	73	13	6	4	8	7
Wood	kt / year (dry)	672	526	298	195	85	77	58	75	58
Human waste treatment, Septic tank sludge	kt / year (dry)	78	51	46	47	17	15	17	11	12
Tsunami sediment	kt / year (dry)	0	0	0	0	0	0	0	7	9
Digested sewage sludge	kt / year (dry)	59	50	31	11	4	3	3	5	5
Other sewage sludge	kt / year (dry)	219	185	114	42	17	17	17	34	22
Waterworks sludge	kt / year (dry)	199	166	146	66	67	67	67	67	67
Organic sludge from manufacturing	kt / year (dry)	347	156	69	48	23	22	31	39	27
Livestock waste	kt / year (dry)	12	12	11	11	11	14	11	11	12
Total	kt / year (dry)	3,367	2,643	1,837	1,162	702	598	588	616	552

As indicated in Table 8-6, 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 I FY1980, 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 8-6.

Table 8-6 Overview of data for the amount of biodegradable waste disposed of in landfill

Item		Data source	MSW	ISW	Remarks
Food waste		*Research on the State of Wide-range Movement and Cyclical Use of Wastes* (MoEJ)	Calculated by multiplying total amount of corresponding landfilled waste by the composition ratio of each waste type	- Amount of animal and plant residues directly landfilled and after intermediate processing. - Amount of livestock carcasses directly landfilled	- Estimated by interpolation for some fiscal years, - Substituted FY1980 value for the years prior to FY1980
Paper/ Cardboard				Amount of waste paper directly landfilled	
Wood				Amount of waste wood directly landfilled	
Textiles (natural fiber)			Calculated by multiplying by the ratio of natural fiber textiles in textile products each year from "*Annual Textile Statistics Report*"	Amount of waste natural fiber textiles directly landfilled (considering all the amount as waste natural fiber textiles due to the Waste Disposal and Pubic Cleansing Law	
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)	*Research on the State of Wide-range Movement and Cyclical Use of Wastes* (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
Digested sewage sludge		*Data provided by METI*		Compiled and provided by MLITT	- 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 the *Voluntary Action Plan on Environment), Follow-up Action Result* (Japan Federation of Economic Organizations) - 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 which can identify the carbon content of waste more precisely. The percentages of water content by each type of waste to estimate activity data on a dry basis and its sources are given in Table 8-7. In order to estimate the CO_2 emissions for the category "8.4., Waste Incineration (6C)" as well as this source category, dry basis activity are used for the same reason.

Table 8-7 Percentage of water content in waste disposed of in controlled landfill sites

Items		Water content [%]	Source
Food waste		75 (direct final disposal)	Water percentage of food waste in *Cyclical Use of Waste Report*
		70 (final disposal after treatment)	Expert judgment
Paper/ Cardboard		20 (MSW) 15 (ISW)	Expert judgment
Wood		45	Expert judgment
Textiles (natural fiber)		20 (MSW) 15 (ISW)	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)	Determined by specialists
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		
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)	Determined by specialists
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 ISW Landfill Sites by Site Structure Type***

The percentages of landfill sites by site structure type for MSW are determined by referring to 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*), which lists Japan's MSW disposal sites in the section "Facility by Type (Final Disposal Sites)", regarding as semi-aerobic those sites which have leachate treatment facilities and subsurface containment structures, and regarding the percentage of semi-aerobic landfill disposal volume to be the percentage of their total landfill capacity [m^3].

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.

Table 8-8 Percentages of MSW landfill sites by site structure

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Anaerobic landfill percentage	%	74.2	64.2	54.4	43.5	41.5	36.5	36.1	38.7	38.7
Semi-aerobic landfill percentage	%	25.8	35.8	45.6	56.5	58.5	63.5	63.9	61.3	61.3

- ***Percentages of ISW Landfill Sites by Site Structure Type***

The percentages of landfill sites by site structure type for ISW are determined as indicated below:

- For the period FY2008 and after, they are determined based on the ISW 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 8-9 Percentages of ISW landfill sites by site structure

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Anaerobic landfill percentage	%	90.2	81.1	66.4	48.3	45.8	36.9	47.0	36.7	36.7
Semi-aerobic landfill percentage	%	9.8	18.9	33.6	51.7	54.2	63.1	53.0	63.3	63.3

➢ ***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 #54), 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 was applied. The half-life for tsunami sediment is substituted the half-life of wood by expert judgment.

Table 8-10 Decomposition half-life for biodegradable waste

Item		Half-life [year]	Data source
Food waste		3	Ito (1992)
Paper/cardboard		7	
Wood		7	
Textiles (natural fiber)		36	
Sludge	Tsunami sediment	36	Substituted the half-life of wood 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 since the waste is landfilled until the decomposition actually occurs. As no research is found for making it possible to set a delay time specific to Japan, the default value (6 months) given in the *2006 IPCC Guidelines* was used.

Table 8-11 Amount of biodegraded waste decomposed in each year (Activity data)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Food waste	kt / year (dry)	520	518	453	315	212	184	160	140	125
Paper/ Cardboad	kt / year (dry)	1,264	1,212	1,057	892	780	743	703	665	632
Textiles (natural fiber)	kt / year (dry)	75	69	61	59	56	52	47	43	40
Wood	kt / year (dry)	349	385	385	373	362	357	351	346	341
Human waste treatment, Septic	kt / year (dry)	111	84	64	51	41	37	33	30	27
Tsunami sediment	kt / year (dry)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Digested sewage sludge	kt / year (dry)	63	58	47	31	21	18	16	13	13
Other sewage sludge	kt / year (dry)	234	219	176	114	78	68	59	52	49
Waterworks sludge	kt / year (dry)	192	185	157	120	97	92	88	84	80
Organic sludge from	kt / year (dry)	365	293	183	118	85	74	65	60	56
Livestock waste	kt / year (dry)	12	12	12	11	11	11	11	11	11
Total	kt / year (dry)	3,184	3,035	2,595	2,085	1,742	1,635	1,533	1,445	1,374

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 ISW, 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.

$$R = r \times f \times 16/ 22.4 / 1,000$$

Where:

R : Amount of CH_4 recoved 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 was 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 was used for FY1997 through FY2004.

Table 8-12 Amount of CH_4 recovered at landfill sites in Japan

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Amount of gaseous use	km^3 N	1,985	2,375	2,372	140	1,161	1,154	1,266	1,032	1,681
CH_4 ratio	%	53.3	42.2	40.0	48.5	37.1	40.0	43.8	51.2	49.5
Amount of CH_4 use	km^3 N	1,059	1,003	949	68	431	462	555	528	832
CH_4 unit conversion	Gg-CH_4	0.76	0.72	0.68	0.05	0.31	0.33	0.40	0.38	0.59

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 Rate 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 ISW in Japan. Therefore, the default oxidation factor for managed landfill sites (0.1) was used in accordance with the 2006 IPCC Guidelines.

c) *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The uncertainty in emission factors was evaluated by integrating the uncertainties for carbon content, fraction of degradable organic carbon dissimilated, CH_4 correction factor, and percentage of CH_4 in generated gas, and estimated to be in the range of 42.4-108.6%. The uncertainty in activity data was evaluated by integrating the uncertainties for the residual amount of biodegradable waste (landfilled amount and percentage of water content in waste) at the end of the year before the reporting year and the methane generation rate constant for the reporting year, and estimated to be in the range of 31.7-56.6%. As a result, the uncertainty in the emissions from solid waste disposal sites was estimated to be in the range of 53-113%.

The methods for evaluation of the uncertainty levels for each component are:

- Use of 95% confidence interval of actual measurement data: carbon content (food waste, paper/cardboard and wood)
- Use of the statistical uncertainties: domestic demand for textiles and landfilled amount of biodegradable waste
- Based on expert judgment: carbon content (sewage sludge, human waste treatment sludge and organic sludge from manufacturing industries), fraction of degradable organic carbon dissimilated, percentage of CH_4 in landfill gas and percentage of water content in biodegradable waste
- Use of the default values in the IPCC Guidelines: carbon content (livestock waste) and CH_4 correction factor
- Use of the values set by the Committee for GHGs Emissions Estimation Methods: carbon content (waterworks sludge)
- Use of the differences between the adopted values and default ones: residual amount of biodegradable waste

For more details about basic methods for uncertainty assessment in Japan, see the Annex 7.

● ***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) *Source-specific QA/QC and Verification*

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e) *Source-specific Recalculations*

- The amounts of tsunami sediment disposal were added in the source on the category.
- Updating the data on the amount of waste landfilled for FY1999, 2007, 2010 and 2011, emission estimates for FY2000- 2011 were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector”

f) *Source-specific Planned Improvements*

Further improvements are planned owing to a lack of sufficient current information. Major issues are:

- Determining the value of methane correction factor taking into account the conditions of the management of landfill sites
- 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

8.2.2. Emissions from Unmanaged Waste Disposal Sites (6.A.2.)

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.

8.2.3. Emissions from Other Managed Landfill Sites (6.A.3.)

8.2.3.1. Emissions from Inappropriate Disposal (6.A.3.a)

a） ***Source/Sink Category Description***

In Japan, the definition of “inappropriate disposal” is waste disposal violating the Waste Disposal and Public Cleansing Act (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 Revised 1996 IPCC Guidelines, CH4 emissions from inappropriate disposal are reported under “Other (6.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 “Emissions from Controlled Disposal Sites (6.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 is used for the anaerobic disposal sites for “wood emissions from managed disposal sites”.

- ***Activity Data***

Activity data (dry basis) was 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 8-13 Activity data of inappropriately disposed wood (dry basis)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Activity data	kt (dry)	2.3	5.5	16.0	15.7	14.1	13.1	13.1	13.2	13.4

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 “Emissions from Controlled Landfill Sites” (6.A.1). The uncertainty in the CH_4 emissions from inappropriate disposal was estimated to be 79%. For more details, see the Annex 7.

● ***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) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e) ***Source-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 for the period FY2007- 2011 are recalculated.

f) ***Source-specific Planned Improvements***

For future inventories, long-term efforts on further scientific investigations will be made to identify country-specific parameters.

8.3. Wastewater Handling (6.B.)

The CH_4 and N_2O emissions from wastewater handling are estimated in the “Wastewater Handling (6.B.)”. The target categories are shown in Table 8-14. 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. Therefore, total emission amount is reported in the subcategory “Wastewater” in CRF, 6.B.; while IE is reported in the subcategory “Sludge”.

Table 8-14 Categories overview for wastewater handling (6.B.)

<table>
<tr><th>Category</th><th>Type Estimated</th><th colspan="2">Forms of Treatment</th><th>CH_4</th><th>N_2O</th></tr>
<tr><td rowspan="2">6.B.1. (8.3.1)</td><td>Industrial wastewater (8.3.1.1)</td><td colspan="2">(Sewage treatment plants)</td><td>○</td><td>○</td></tr>
<tr><td>Landfill leachate treatment (8.3.1.1)</td><td colspan="2">Landfill leachate treatment</td><td>○</td><td>○</td></tr>
<tr><td rowspan="17">6.B.2. (8.3.2)</td><td rowspan="12">Domestic/commercial wastewater</td><td colspan="2">Sewage treatment plants (8.3.2.1)</td><td>○</td><td>○</td></tr>
<tr><td rowspan="4">Domestic wastewater treatment facilities (mainly septic tanks) (8.3.2.2)</td><td>Community plant</td><td>○</td><td>○</td></tr>
<tr><td>Gappei-shori johkasou</td><td>○</td><td>○</td></tr>
<tr><td>Tandoku-shori johkasou</td><td>○</td><td>○</td></tr>
<tr><td>Vault toilet</td><td>○</td><td>○</td></tr>
<tr><td rowspan="6">Human waste treatment facilities (8.3.2.3)</td><td>High-load denitrification treatment</td><td>○</td><td>○</td></tr>
<tr><td>Membrane separation</td><td>○</td><td>○</td></tr>
<tr><td>Anaerobic treatment</td><td>○</td><td rowspan="4">○</td></tr>
<tr><td>Aerobic treatment</td><td>○</td></tr>
<tr><td>Standard denitrification treatment</td><td>○</td></tr>
<tr><td>Other</td><td>○</td></tr>
<tr style="display:none"></tr>
<tr><td rowspan="5">Degradation of domestic wastewater in nature (8.3.2.4)</td><td rowspan="3">Discharge of untreated domestic wastewater</td><td>Tandoku-shori johkasou</td><td>○</td><td>○</td></tr>
<tr><td>Vault toilet</td><td>○</td><td>○</td></tr>
<tr><td>On-site treatment</td><td>○</td><td>○</td></tr>
<tr><td rowspan="2">Sludge disposal at sea*</td><td>Human waste sludge</td><td>○</td><td>○</td></tr>
<tr><td>Sewage sludge</td><td>○</td><td>○</td></tr>
</table>

Note: *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 8-15. In FY2012, emissions from this source category are 2,639 Gg-CO_2 eq. and accounted for 0.2% of the national total emissions (excluding LULUCF). The emissions from this source category decreased by 27.9% 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 (6.B.2.a)" for FY1995 through FY1998 increased.

Table 8-15 GHG emissions from wastewater handling (6.B.)

Gas	Category	Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CH_4	6.B.1. Industrial waste water	(Sewage treatment plants)	Gg-CH_4	5.2	5.1	5.0	4.9	4.9	4.7	4.6	4.6	4.6
		Landfill leachate treatment	Gg-CH_4	1.2	1.2	1.1	0.8	0.6	0.4	0.4	0.3	0.3
	6.B.2. Domestic/commercial wastewater	Sewage treatment plants	Gg-CH_4	8.6	9.9	11.1	12.1	12.4	12.7	12.7	12.7	12.1
		Domestic waste water treatment facilities (mainly septic tank)	Gg-CH_4	33.8	35.0	38.8	32.8	33.2	32.7	32.9	32.9	32.9
		Humanwaste treatment facilities	Gg-CH_4	5.2	3.2	1.8	1.0	0.7	0.7	0.6	0.5	0.5
		Degradation of domestic wastewater in nature	Gg-CH_4	60.2	50.8	39.5	28.7	23.9	22.4	21.1	20.0	19.3
	Total		Gg-CH_4	114.4	105.1	97.3	80.2	75.8	73.6	72.2	71.0	69.7
			Gg-CO_2 eq	2,402	2,207	2,043	1,685	1,592	1,545	1,517	1,491	1,464
N_2O	6.B.1. Industrial waste water	(Sewage treatment plants)	Gg-N_2O	0.39	0.38	0.33	0.39	0.41	0.39	0.38	0.38	0.38
		Landfill leachate treatment	Gg-N_2O	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
	6.B.2. Domestic/commercial wastewater	Sewage treatment plants	Gg-N_2O	1.39	1.55	1.58	1.67	1.69	1.70	1.67	1.67	1.55
		Domestic waste water treatment facilities (mainly septic tank)	Gg-N_2O	1.58	1.65	1.70	1.78	1.76	1.72	1.72	1.71	1.70
		Humanwaste treatment facilities	Gg-N_2O	0.22	0.26	0.12	0.02	0.02	0.02	0.02	0.02	0.02
		Degradation of domestic wastewater in nature	Gg-N_2O	0.44	0.35	0.27	0.19	0.16	0.15	0.14	0.13	0.13
	Total		Gg-N_2O	4.05	4.21	4.01	4.08	4.04	3.99	3.94	3.91	3.79
			Gg-CO_2 eq	1,256	1,307	1,244	1,263	1,253	1,236	1,221	1,213	1,175
Total of all gases			Gg-CO_2 eq	3,658	3,514	3,286	2,948	2,844	2,781	2,738	2,704	2,639

8.3.1. Industrial Wastewater (6.B.1.)

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 (6.B.1.a)” and CH_4 and N_2O emissions from landfill leachate treatment are allocated to “Landfill leachate treatment (6.B.1.b)” under the sub-category of “Industrial Wastewater (6.B.1)”.

8.3.1.1. Industrial Wastewater (6.B.1.a)

a） ***Source/Sink 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 (6.B.1.a).”

b） ***Methodological Issues***

- ***Estimation Method***

In accordance with the GPG (2000) decision tree, CH_4 and N_2O emissions are estimated for the industries that release organic-rich wastewater. Since default values given in the Revised 1996 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 "8.3.2.1. Emissions from Treatment of Domestic and Commercial Wastewater (at sewage treatment plants) (6.B.2.a)" because CH_4 and N_2O generation processes from both sources are considered to be closely resemble[2].

Since the ones used in "6.B.2.a" 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) was used.

For the nitrogen concentration of runoff water, 37.2 mg-N/L was used, which was 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]

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 was 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

[2] As described in the following section, although N_2O emission factors for the treatment of domestic and commercial wastewater at sewage treatment plants are developed in the inventory of this annual submission (2013), there has been no change to the N_2O emission factor for industrial wastewater treatment (Reference #7).

generated from anaerobic treatment defined in *the 2006 IPCC Guidelines*.

- ***Activity Data***

The activity data for CH4 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 8-16). The amount of organic matter was 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 was used for this source.

CH_4 Activity data
= ∑[(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
= ∑[(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 Burdens Generated* (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 was 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) was 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 8-16 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 8-17 BOD load [kt-BOD] and TN load [kt-N] of industrial wastewater

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
BOD load	kt-BOD	1,075	1,046	1,032	1,000	1,004	970	946	946	946
TN load	kt N	89	87	76	89	94	90	89	89	89

c) ***Uncertainties and Time-series Consistency***

● ***Uncertainties***

The level of uncertainty in the CH_4 emission factor was evaluated on the basis of expert judgment. The uncertainty in activity data was estimated to be 37.4% on the basis of the uncertainties in the amount of wastewater used, percentage of industrial wastewater treated at CH_4-generating facilities, percentage of wastewater treated on-site, and BOD concentration in runoff water provided by each middle classification industry. The uncertainties in the amount of wastewater used, percentage of industrial wastewater treated at facilities generating CH_4, and BOD concentration in runoff water are estimated by using statistical uncertainty. The uncertainty in the percentage of wastewater treated on-site was determined by expert judgment. The uncertainty level for N_2O is evaluated by the same method as was used for the CH_4 and estimated to be 300% and 51.1% for emission factor and activity data, respectively. The uncertainties in CH_4 and N_2O emissions from industrial wastewater handling are estimated to be 71% and 304%, respectively. For details, see the Annex 7.

- ***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） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the GPG (2000). The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

No recalculations are conducted.

f） ***Source-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

8.3.1.2. Landfill Leachate Treatment (6.B.1.b)

a） ***Source/Sink Category Description***

CH_4 and N_2O emissions from landfill leachate treatment in MSW and ISW landfill sites are estimated and allocated to “Landfill leachate treatment (6.B.1.b).”

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 ISW 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:

$E = EF \times Li$

Where:

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 ISW 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*.

$$EF_{CH4} = B_0 \times MCF$$
$$= 0.6\ [\text{kg-}CH_4/\text{kg-BOD}] \times 0.8$$
$$= 0.48\ [\text{kg-}CH_4/\text{kg-BOD}]$$

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.

$$EF_N = 0.005\ [\text{kg-}N_2O\text{-N/kg N}] \times 44/28$$
$$= 0.0079\ [\text{kg-}N_2O/\text{kg N}]$$

- ***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 #15), 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 ISW 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 ISW 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 #15

W : Amount of organic waste landfilled with or without intermediate treatments including incineration ash [t/year] obtained by t*he Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*

T_i : Ratio of leachate to be biologically treated in landfill site [%] determined to be 87.6% based on Reference #15

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 ISW 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 #15

W : Amount of organic waste landfilled with or without intermediate treatments including incineration ash [t/year] obtained by *the Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*

T_i : Ratio of leachate to be biologically treated in landfill site [%] determined to be 87.6% based on Reference #15

Table 8-18 BOD load [kt-BOD] and TN load [kt-N] of industrial wastewater

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
BOD load	kt-BOD	2.6	2.5	2.2	1.6	1.3	0.8	0.8	0.6	0.6
TN load	kt-N	3.5	3.3	3.0	2.2	1.7	1.1	1.1	0.8	0.8

c） ***Uncertainties and Time-series Consistency***

- ***Uncertainties***

The level of uncertainty in the CH_4 emission factor was estimated by using the uncertainties in the maximum CH_4 generation potential and the CH_4 correction factor. The default value in the *2006 IPCC Guidelines* was used for uncertainty in the N_2O emission factor. The uncertainties in activity data are evaluated for *tandoku-shori*, vault toilets, on-site disposal (determined from the wastewater treatment population and unit BOD or nitrogen in domestic wastewater) and ocean dumping (amount of human waste and septic tank sludge dumped into ocean, and concentration of organic matter or nitrogen in human waste and septic tank sludge). The methods of evaluation of the uncertainty levels for each component are:

- Use of the default values in the 2006 IPCC Guidelines: maximum CH_4 generation potential and CH_4 correction factor
- Based on expert judgment: unit BOD and nitrogen in domestic wastewater
- Use of 95% confidence interval of actual measurement data: concentrations of organic matter and nitrogen in human waste and septic tank sludge
- Use of the statistical uncertainties: wastewater treatment population, amount of human waste and septic tank sludge dumped into ocean

The uncertainties in CH_4 and N_2O emissions from natural decomposition of domestic wastewater are estimated to be 76%. For more details, see the Annex 7.

- ***Time-series Consistency***

As described in detail in the preceding sections, emissions are calculated in a consistent manner.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e） ***Source-specific Recalculations***

Updating the data on the amount of waste landfilled for FY1999, 2007, 2010 and 2011, emission estimates for the said fiscal years were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector”.

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.3.2. Domestic and Commercial Wastewater (6.B.2.)

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 (6.B.2.)”. 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 71.5% of the population at the end of FY2012.

Domestic wastewater treatment systems (e.g. *gappei shori jokasou*) are being promoted as an effective means of supplementing sewerage systems in smaller municipalities with low population densities and little flat land. In FY2012, septic tanks (*jokasou*) are used by 21.3% of the population, with the remainder being treated after collection or on-site.

In CRF (6.B.2.), N_2O emissions from human waste treatment plants are reported in the subcategory “Human sewage (6.B.2.2)”, and other emissions are reported in “Domestic and Commercial (w/o human sludge) (6.B.2.1)”.

“NE” 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.

8.3.2.1. Sewage Treatment Plant (6.B.2.a)

a） ***Source/Sink 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 *GPG (2000)* (Page 5.14, Fig. 5.2). 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).

$$EF_{CH4} = EF_{WWTT} + EF_{SSTT}$$
$$= 8.764 \times 10^{-4} \text{ [kg-CH}_4\text{/m}^3\text{]}$$

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 #16).

$$EF_{N2O} = EF_{WWTTi} + EF_{SSTT}$$

EF_{N2O} : N_2O Emission factor
EF_{WWTTi} : Emission factor for wastewater treatment process *i* (Table 8-19)
EF_{SSTT} : Average of emission factor for sludge treatment process (0.6 [mg-N_2O/m^3])

Table 8-19 N_2O Emission factor by wastewater treatment process at sewage treatment plant

Wastewater treatment process	Unit [mg-N_2O/m^3]	N_2O Emission factor (WWT-P and ST-P) Unit [mg-N_2O/m^3]
[a] Standard activated sludge process	142	142.6
[b] Anaerobic-aerobic activated sludge process	29.2	29.8
[C] Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process	11.7	12.3
[d] Recycled nitrification-denitrification membrane bioreactor	0.5	1.1

Note:

a) Includes all the wastewater treatment processes other than b), c), and d).

c) 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 8-20 Activity data for wastewater treated at sewage treatment plant

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Standard activated sludge process	10^6 m^3	9,761	10,780	10,686	11,405	11,508	11,552	11,358	11,288	10,485
Anaerobic-aerobic activated sludge process	10^6 m^3	73	446	1,523	1,039	809	868	909	909	953
Anaerobic-anoxic-oxic process and recycled nitrification; denitrification process	10^6 m^3	23	89	487	1,374	1,858	2,049	2,181	2,308	2,355
Recycled nitrification-denitrification membrane bioreactor	10^6 m^3	0	0	0	0	1	1	2	20	20
Total	10^6 m^3	9,857	11,316	12,696	13,818	14,176	14,470	14,450	14,525	13,813

c) ***Uncertainties and Time-series Consistency***

● ***Uncertainties***

The uncertainties in CH_4 and N_2O emission factors are estimated by using the 95% confidence interval of actual measurement data. The uncertainty in activity data is evaluated based on the annual throughput and annual primary treatment amount and estimated by using the statistical uncertainties. The uncertainties in CH_4 and N_2O emissions from sewage treatment plants are estimated to be 33% and 146%, respectively. For details, see the Annex 7.

● ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e) ***Source-specific Recalculations***

Updating the data on the amount of treated wastewater for FY 2011, emission estimates for the said fiscal year were recalculated. For detail, see the section "8.1.3. General Recalculations for Emissions from Waste Sector".

f) ***Source-specific Planned Improvements***

No improvements are planned.

8.3.2.2. Domestic Sewage Treatment Plant (Mainly Septic Tanks) (6.B.2.b)

a) ***Source/Sink 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. The *gappei-shori* processes feces and urine and miscellaneous wastewater, whereas *tandoku-shori* processes only feces and urine. A community plant is small-scale sewage facility, where urine and the miscellaneous wastewater of each region are processed.

Table 8-21 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 (6.B.2.c)”.

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 *GPG (2000)* (Page 5.14, Fig. 5.2). Emissions are calculated by multiplying the annual population of treatment for each type of domestic sewage treatment plant by the emission factor.

$$E = \sum \left(EF_i \times A_i \right)$$

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 8-22 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 #17) 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 #18), 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 8-23 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 #17 and Reference #18. 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 8-24 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 #17 and Reference #18. 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 8-25 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 8-26 Annual treatment population by type of domestic sewage treatment plant (1,000 persons)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Community plant	1000 person	493	398	414	552	416	297	293	286	289
Gappei-shori johkasou	1000 person	7,983	8,515	10,806	12,792	13,854	13,792	14,082	14,276	14,340
Tandoku-shori johkasou	1000 person	25,119	26,105	23,289	18,303	15,413	14,712	13,948	13,316	13,051
Vault toilet	1000 person	38,920	29,409	20,358	13,920	11,301	10,671	9,984	9,348	8,850
Total	1000 person	72,515	64,427	54,867	45,567	40,984	39,472	38,307	37,226	36,530

c） *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of uncertainty in the emission factor is evaluated for each treatment facility taking into account the actual measurement data and setting methods. The following data are used:

- The 95% confidence interval of actual measurement data: gappei-shori (N_2O) and tandoku-shori (CH_4 and N_2O)
- The upper and lower limits of actual measurement data: community plants (CH_4) and gappei-shori (CH_4)
- The values set by the Committee for GHGs Emissions Estimation Methods: community plants (N_2O) and vault toilets (CH_4 and N_2O)

The uncertainty in activity data is evaluated based on the uncertainties in treatment population for each type of treatment facilities by using the statistical uncertainty (10%). The uncertainties in CH_4 and N_2O emissions from domestic wastewater treatment (mainly septic tanks) are estimated to be 87% and 72%, respectively. For details, see the Annex 7.

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e) ***Source-specific Recalculations***

- Updating the annual treatment population by type of domestic sewage treatment plant for FY2002, 2003, 2004, 2005, 2007 and 2011, emission estimates from community plants for the said fiscal years were recalculated. For detail, see the section "8.1.3. General Recalculations for Emissions from Waste Sector"

f) ***Source-specific Planned Improvements***

No improvements are planned.

8.3.2.3. Human-Waste Treatment Plant (6.B.2.c)

a) ***Source/Sink 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) ***CH_4***

- ***Estimation Method***

Emissions of CH_4 from this source are calculated using Japan's country-specific methodology in accordance with decision tree of the GPG (2000) (Page 5.14, Fig. 5.2). Emissions are calculated by multiplying the volume of domestic wastewater treated at human waste treatment plants by the emission factor.

$$E = \sum \left(EF_i \times A_i \right)$$

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 8-27 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 #36 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 #66
High load de-nitrification treatment	0.005	Reference #66
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 8-29), 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 8-25) by the capacity of each treatment process (Table 8-26).

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 8-28 Volume of human waste and septic tank sludge treated at their treatment plants

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Vault toilet	1000 kl/year	20,406	18,049	14,673	10,400	8,894	8,353	7,917	7,365	7,015
ST sludge	1000 kl/year	9,224	11,545	13,234	13,790	14,064	13,989	13,760	13,547	13,511
Total	1000 kl/year	29,630	29,594	27,907	24,190	22,958	22,342	21,677	20,912	20,526

Table 8-29 Trends in treatment capacity by treatment process

Unit	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Anaerobic treatment	kl/day	34,580	19,869	10,996	6,476	4,444	4,144	3,891	3,265	3,039
Aerobic treatment	kl/day	26,654	19,716	12,166	8,465	7,535	6,961	6,753	6,200	6,469
Standard denitrification	kl/day	25,196	30,157	31,908	29,655	27,737	27,748	26,173	25,694	25,538
High-intensity denitrification	kl/day	8,158	13,817	16,498	17,493	14,938	16,285	16,104	15,778	15,030
Membrane separation	kl/day	0	1,616	2,375	3,055	3,650	3,573	3,684	3,684	4,062
Other	kl/day	13,777	20,028	25,917	30,277	35,441	34,654	34,577	34,622	33,616

Table 8-30 Activity Data for human waste by treatment type

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Anaerobic treatment	1000 kl/year	9,455	5,589	3,073	1,642	1,088	992	925	765	711
Aerobic treatment	1000 kl/year	7,288	5,546	3,400	2,146	1,845	1,666	1,605	1,453	1,513
Standard denitrification	1000 kl/year	6,889	8,483	8,917	7,518	6,793	6,640	6,222	6,021	5,973
High-intensity denitrification	1000 kl/year	2,231	3,887	4,611	4,435	3,658	3,897	3,828	3,697	3,516
Membrane separation	1000 kl/year	0	455	664	774	894	855	876	863	950
Other	1000 kl/year	3,767	5,634	7,243	7,676	8,679	8,293	8,220	8,113	7,863
Total	1000 kl/year	29,630	29,594	27,907	24,190	22,958	22,342	21,677	20,912	20,526

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 *GPG (2000)* (Page 5.14, Fig. 5.2). Emissions are calculated by multiplying the volume of nitrogen treated at human waste treatment plants, by the emission factor.

$$E = \sum (EF_i \times A_i)$$

E : Emission of nitrous oxide from the processing of domestic and commercial wastewater human waste 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 was treatment plants (by 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 8-31 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[a]	Calculated by interpolation using the values of FY1994 and FY2003	0.0029[b]
Membrane separation	0.033[a]	Calculated by interpolation using the values of FY1994 and FY2003	0.0024[b]
Other (including anaerobic treatment, aerobic treatment, standard de-nitrification treatment)	0.0000045[c]		

Note:

a) Use median value of actual measurements at 13 plants given in Reference #67

b) Use median value of actual measurements at 13 plants given in Reference #59

c) Referred to Reference #66 (Calculated by dividing upper limit value for standard de-nitrification treatment (0.00001 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 was 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 8-28).

➢ ***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 8-29).

➢ ***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 8-32).

Table 8-32 Concentration of nitrogen contained in collected human waste and sewage in sewerage tank

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Vault toilet	mg-N/l	3,940	3,100	2,700	2,700	2,700	2,700	2,700	2,700	2,700
ST sludge	mg-N/l	1,060	300	580	580	580	580	580	580	580
Weighted average	mg-N/l	3,043	2,008	1,695	1,491	1,401	1,373	1,354	1,327	1,305

Table 8-33 Activity data: Amount of nitrogen in human waste processed at human waste treatment plants and septic tank sludge

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Anaerobic treatment	kt-N	28.8	11.2	5.2	2.4	1.5	1.4	1.3	1.0	0.9
Aerobic treatment	kt-N	22.2	11.1	5.8	3.2	2.6	2.3	2.2	1.9	2.0
Standard denitrification	kt-N	21.0	17.0	15.1	11.2	9.5	9.1	8.4	8.0	7.8
High-intensity denitrification	kt-N	6.8	7.8	7.8	6.6	5.1	5.3	5.2	4.9	4.6
Membrane separation	kt-N	0	0.9	1.1	1.2	1.3	1.2	1.2	1.1	1.2
Other	kt-N	11.5	11.3	12.3	11.4	12.2	11.4	11.1	10.8	10.3
Total	kt-N	90.2	59.4	47.3	36.1	32.2	30.7	29.4	27.7	26.8

c) ***Uncertainties and Time-series Consistency***

- ***Uncertainties***

The level of uncertainty in the CH_4 emission factor is evaluated by using the default values set by the Committee for GHGs Emissions Estimation Methods for each type of human waste treatment method (anaerobic treatment, aerobic treatment, standard denitrification, high-intensity denitrification, membrane separation, and other). The uncertainty in the activity data for CH_4 is associated with uncertainties in the amount of human waste and septic tank sludge that entered human waste treatment facilities and the throughput capacity rate by type of human waste treatment. The uncertainties for each component are estimated by using the statistical uncertainties. The uncertainty level in N_2O emission factors is also evaluated by treatment type. For high-intensity denitrification and membrane separation, the 95% confidence interval of actual measurement data on emission factors is used. For other treatments, the default values set by the Committee for GHGs Emissions Estimation Methods are used. The uncertainty in activity data for N_2O is estimated by using the uncertainties in nitrogen concentration in human waste and septic tank sludge that determined from the standard deviations in actual measurement data, in addition to the components of uncertainty for CH_4. The uncertainties in CH_4 and N_2O emissions from human waste treatment are estimated to be 101% and 106%, respectively. For details, see the Annex 7.

- ***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 8-31. For other parameters, data are constructed consistently for the entire time series. The emissions are calculated in a consistent manner.

d) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the GPG (2000). The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e) ***Source-specific Recalculations***

Updating the data on the amount of human waste processed for FY2011, emission estimates for the said fiscal year were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector”

f) ***Source-specific Planned Improvements***

No improvements are planned.

8.3.2.4. Emission from the Natural Decomposition of Domestic Wastewater (6.B.2.d)

a) ***Source/Sink 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 8-34. Estimated activity data are shown in Table 8-35.

Table 8-34 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	User population [persons] × Unit BOD from domestic wastewater [g-BOD/person·day]	User population [persons] × Unit nitrogen from domestic wastewater [g-N/person·day]
Vault toilet		
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)	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 #43

BOD concentration and nitrogen concentration in human waste and septic tank sludge: Reference #58

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 emission from soil (4.D.)" category in the Agriculture section, and therefore, not included in the calculation for this source.

Table 8-35 Activity data: Amount of organic material and nitrogen in domestic wastewater untreated and discharged into public water body

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Tandoku-shori	kt-BOD	366.7	381.1	341.0	267.2	225.6	214.8	203.6	194.4	191.1
Vault toilet	kt-BOD	568.2	429.4	298.0	203.2	165.4	155.8	145.8	136.5	129.6
On-site disposal	kt-BOD	46.2	21.0	9.4	3.9	7.6	2.0	1.9	1.6	1.6
Ocean dumping (Human waste)	kt-BOD	21.7	13.5	9.3	3.5	0	0	0	0	0
Ocean dumping (sewege sludge)	kt-BOD	0.8	0.9	0.0	0	0	0	0	0	0
Total	kt-BOD	1,002.9	845.1	657.7	477.8	398.7	372.6	351.3	332.5	322.2

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Tandoku-shori	kt-N	18.3	19.1	17.0	13.4	11.3	10.7	10.2	9.7	9.6
Vault toilet	kt-N	28.4	21.5	14.9	10.2	8.3	7.8	7.3	6.8	6.5
On-site disposal	kt-N	2.3	1.1	0.5	0.2	0.4	0.1	0.1	0.1	0.1
Ocean dumping (Human waste)	kt-N	7.2	3.2	2.2	0.8	0	0	0	0	0
Ocean dumping (sewege sludge)	kt-N	0.1	0.1	0.0	0	0	0	0	0	0
Total	kt-N	56.3	44.7	34.6	24.5	19.9	18.6	17.6	16.6	16.1

c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of uncertainty in the CH_4 emission factor is estimated by using the uncertainties in the maximum CH_4 generation potential and the CH_4 correction factor. The default value in the *2006 IPCC Guidelines* is used for uncertainty in the N_2O emission factor. The uncertainties in activity data are evaluated for *tandoku-shori*, vault toilets, on-site disposal (determined from the wastewater treatment population and unit BOD or nitrogen in domestic wastewater) and ocean dumping (amount of human waste and septic tank sludge dumped into ocean, and concentration of organic matter or nitrogen in human waste and septic tank sludge). The methods of evaluation of the uncertainty levels for each component are:

- Use of the default values in the 2006 IPCC Guidelines: maximum CH_4 generation potential and CH_4 correction factor
- Based on expert judgment: unit BOD and nitrogen in domestic wastewater
- Use of 95% confidence interval of actual measurement data: concentrations of organic matter and nitrogen in human waste and septic tank sludge
- Use of the statistical uncertainties: wastewater treatment population, amount of human waste and septic tank sludge dumped into ocean

The uncertainties in CH_4 and N_2O emissions from natural decomposition of domestic wastewater are estimated to be 76%. For more details, see the Annex 7.

● ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

Updating the data the annual treatment population of *Tandoku-shori johkasou*/Vaults for FY2002, 2003, 2004, 2007 and 2011, and the data on the amount of human waste processed for FY2011, emission estimates for the said fiscal years are recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector.”

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.3.2.5. Recovery of CH_4 Emitted from Treating Domestic and Commercial Wastewater (Reference Value) (6.B.2.-)

a） ***Source/Sink Category Description***

In Japan, CH_4 emissions generated from sludge digestion at sewage treatment plants and human waste treatment facilities are entirely recovered.

CH_4 emissions are estimated by using Japan’s country specific methodology with CH_4 emission factors on the basis of actual measurements of CH_4 emissions from the facilities to the atmosphere in. For details, see the section “8.3.2.1. Sewage Treatment Plant (6.B.2.a)” and “8.3.2.2. Domestic Sewage Treatment Plant (Mainly Septic Tanks) (6.B.2.b)”. Therefore, it is different from the methodology indicated in the *GPG (2000)* in which CH_4 emissions are calculated by subtracting the amount of CH_4 recovery from the amount of CH_4 generated from domestic and commercial wastewater treatment. Therefore, the amount of CH_4 recovered is indicated in this section for reference purpose only since it is not necessary for emission estimates for this source.

b) *Methodological Issues*

1) *CH_4 Recovery at Sewage Treatment Plants (Reference Value)*

- ***Estimation Method***

The amount of CH_4 recovered from sludge digesters at sewage treatment plants is calculated by multiplying the amount of digester gas (volumetric basis) recovered from digesters by an emission factor that takes into account the concentration of CH_4 in digester gas.

$$R = A \times EF$$

R : Amount of recovered CH_4 at final disposal site [Gg-CH_4]

A : Amount of generated digester gas [m^3]

EF : Emission factor [Gg-CH_4 /m^3]

- ***Emission Factors***

Emission factor is set by finding the weight equivalent of the average CH_4 concentration in digester gas.

$$EF = F_{CH4} \times 16 / 22.4$$

EF : Emission factor [Gg-CH_4 /m^3]

F_{CH4} : Concentration of methane in digester gas (volumetric basis)

The CH_4 concentration in digester gas (volumetric basis) is set at 60% with reference to the *Manual for Developing Plans for Biosolids Utilization (Draft)* (Ministry of Land, Infrastructure, Transport and Tourism).

- ***Activity Data***

The amount of digester gas recovered from sludge digesters at sewage treatment plants is provided by “amount of digester gas generated by sludge treatment facilities” in the *Sewage Statistics (Admin. Ed.)* (Japan Sewage Works Association). Because entire digester gas generated at sewage treatment plants in Japan is recovered, the total amount of generated digester gas is treated as the amount of digester gas recovered. The amount of digester gas used for energy to be included in the energy category is determined from the amount of digester gas listed in “amount of digester gas used in sludge digester facilities” of the *Sewerage Statistics*.

Table 8-36 Amount of CH_4 recovered from sewage treatment plant sludge digesters [Gg-CH_4]

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Recovered CH_4 amount	Gg-CH_4	88.7	110.5	113.3	122.0	130.3	130.2	132.5	133.4	143.6
Portion used as energy	Gg-CH_4	65.3	73.9	75.3	85.0	93.2	92.4	94.5	97.0	100.4

2） ***Methane Recovery from Human Waste Treatment Facilities (Reference Value)***

● ***Estimation Method***

The amount of CH_4 recovery at human waste treatment facilities is obtained by multiplying the amount of recycled biogas at human waste treatment facilities on a volumetric basis by the emission factor taking into account CH_4 concentration in biogas.

$$R = A \times EF$$

R : Amount of CH_4 recovered at human waste treatment facilities [Gg-CH_4]

A : Amount of Recycled Biogas [m^3]

EF : Emission Factor [Gg-CH_4 /m^3]

● ***Emission Factors***

Emission factor is determined by taking into account CH_4 concentration in biogas and molecular weight conversion. CH_4 concentration in biogas is determined to be 60% referring to the *JARUS Reference System for Information of Biomass Recycling Technology* (The Japan Association of Rural Resource Recycling Solutions). Because statistical data are aggregated on a volumetric basis, they are converted into molecular weight given the average temperature at the facilities is 18℃.

$$EF = F_{CH4} \times 16 / 22.4 \times 273 / (273 + 18)$$

EF : Emission factor [Gg-CH_4 /m^3]

F_{CH4} : CH_4 concentration in biogas (volumetric basis)

● ***Activity Data***

For the activity data on CH_4 recovery at human waste treatment facilities, the aggregated amount of recycled biogas at human waste treatment facilities (volumetric basis) provided by *the State of Municipal Waste Treatment Survey*, Ministry of the Environment, Waste Management and Recycling Department is used. The statistical data before FY2005 are not obtained. Therefore, the emissions for FY2004 and before are estimated by applying the amount of CH_4 actually recovered in FY2005 and in the year that facilities started their operation provided by this survey and in FY2005, and also using the amount of human waste (vault toilet) and septic tank sludge treated at the facilities for FY2004 and before.

Table 8-37 Amount of CH_4 recovered at human waste treatment facilities

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Recovered CH_4 amount	Gg-CH_4	0.3	0.5	0.8	0.9	1.6	1.7	1.7	1.9	1.9

c） ***Uncertainties and Time-series Consistency***

● ***Uncertainties***

The assessment is not conducted, as the amount of CH_4 recovered is reported as a reference value.

● ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

Updating the data on the amount of recycled biogas at human waste treatment facilities for FY2011, the amount of CH_4 recovered for the said fiscal year was recalculated. For detail, see the section "8.1.3. General Recalculations for Emissions from Waste Sector."

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4. Waste Incineration (6.C.)

In Japan, waste disposed of has been reduced in volume primarily by incineration. Emissions from waste incineration are categorized as shown in Table 8-38. CO_2, CH_4, N_2O emissions without energy recovery are allocated to this category. Also, waste incineration includes the following practices of waste used as raw material or fuel:

- Energy recovery from waste incineration
- Waste material is used directly as fuel
- Waste material is converted into fuel

Estimated emissions from the sources listed above are allocated to the "Fuel Combustion (Category 1.A.)" in accordance with the Revised 1996 IPCC Guidelines and the GPG (2000).
In order to avoid double-counting or any other confusion, emissions from the categories indicated in Table 8-38 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 8-38 Categories for the calculation of emissions from waste incineration (6.C.)

Incineration	Waste category	Estimation classification		Category to be allocated to	CO_2	CH_4	N_2O
Waste incineration without energy recovery	Municipal solid waste	Plastics	Fossil-fuel derived plastics	6.C.1	○	○[b]	○[b]
			Biomass-based plastics (biogenic)		NA		
		Textiles	Synthetic textile		○		
			Natural fiber (biogenic)		NA		
		Other (biogenic)			NA		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil	6.C.2	○	○	○
			Animal and vegetable oil (biogenic)		NA		
		Plastics	Fossil-fuel derived plastics		○	○	○
			Biomass-based plastics (biogenic)		NA		
		Food waste [Animal and vegetable residues/animal carcasses (biogenic)]			NA	○	○
		Paper/ cardboard (biogenic)			NA	○	○
		Wood (biogenic)			NA	○	○
		Textile	Synthetic textile		IE[c]	IE[c]	IE[c]
			Natural fiber (biogenic)		NA	○	○
		Sludge	Sewage sludge (biogenic)		NA	○	○
			Other than sewage sludge (biogenic)		NA		○
	Specially controlled industrial waste	Hazardous waste (Waste oil)	Fossil-fuel derived oil	6.C.3	○	○	○
			Animal and vegetable oil (biogenic)		NO	NO	NO
		Clinical waste (Infectious waste)	Plastics (Fossil-fuel derived)		○	○	○
			Other (biogenic)		NA	○	○
Waste incineration with energy recovery	Municipal solid waste	Plastics	Fossil-fuel derived plastics	1.A.1	○	○[b]	○[b]
			Biomass-based plastics (biogenic)		NA		
		Textiles	Synthetic textile		○		
			Natural fiber (biogenic)		NA		
		Other (biogenic)			NA		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil		○	○	○
			Animal and vegetable oil (biogenic)		NA		
		Plastics	Fossil-fuel derived plastics		○	○	○
			Biomass-based plastics (biogenic)		NA		
		Food waste [Animal and vegetable residues/animal carcasses (biogenic)]			NA	○	○
		Paper/ cardboard (biogenic)			NA	○	○
		Wood (biogenic)			NA	○	○
		Textile	Synthetic textile		IE[c]	IE[c]	IE[c]
			Natural fiber (biogenic)		NA	○	○
		Sludge	Sewage sludge (biogenic)		NO	NO	NO
			Other than sewage sludge (biogenic)		NA	○	○
	Specially controlled industrial waste				IE[d]	IE[d]	IE[d]
Direct use of waste as fuel	Municipal solid waste	Plastics	Fossil-fuel derived plastics	1.A.1/2	○	○	○
			Biomass-based plastics (biogenic)		NA		
	Industrial solid waste	Waste oil	Fossil-fuel derived oil	1.A.2	○	○	○
			Animal and vegetable oil (biogenic)		NA		
		Plastics	Fossil-fuel derived plastics	1.A.2	○	○	○
			Biomass-based plastics (biogenic)		NA		
		Wood (biogenic)		1.A.2	NA	○	○
	Waste tire	Fossil origin		1.A.1/2	○	○	○
		Biogenic origin			NA		
Use of waste processed as fuel	Refuse derived fuel (RDF・RPF)	Fossil origin		1.A.1/2	○	○	○
		Biogenic origin			NA		

Note:

a) 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 Revised 1996 IPCC Guidelines; instead it is estimated as a reference value and reported under " Biogenic" in Table 6.A,C of the CRF.

b) Estimated in bulk

c) Included in fossil-fuel derived plastics in ISW.

d) Included in "Specially controlled industrial waste" incineration without energy recovery

Estimated greenhouse gas emissions from waste incineration (category 6.C.) are shown in Table 8-39. In FY2012, emissions from waste incineration are 13,636 Gg-CO_2 eq. and accounted for 1.0% of the national total emissions (excluding LULUCF). The emissions from this source category decreased by 1.0% 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 8-39 GHG emissions from waste incineration (6.C.)

Gas	Waste category	Estimation Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	Municipal solid waste	Plastics	Gg-CO_2	5,041	5,031	5,222	3,060	2,542	2,374	2,089	2,408	2,517
		Synthetic textiles	Gg-CO_2	503	539	421	428	548	658	587	648	657
		Other (biogenic)	Gg-CO_2									
	Industrial solid waste	Waste oil	Gg-CO_2	3,652	4,344	4,775	4,249	4,633	3,754	4,023	3,669	3,663
		Plastics	Gg-CO_2	2,120	4,516	4,358	4,311	4,743	3,444	3,917	3,558	3,497
		Other (biogenic)	Gg-CO_2									
	Specially controlled waste	Waste oil	Gg-CO_2	748	1,110	1,636	1,504	1,647	1,334	1,430	1,304	1,302
		Infectious plastics	Gg-CO_2	198	327	426	433	492	357	406	369	364
		Infectious waste (except plastics; biogenic)	Gg-CO_2									
	Total		Gg-CO_2	12,263	15,867	16,838	13,984	14,606	11,922	12,452	11,956	12,000
CH_4	Municipal solid waste		Gg-CH_4	0.46	0.43	0.38	0.06	0.06	0.06	0.06	0.06	0.06
	Industrial solid waste	Waste oil	Gg-CH_4	0.006	0.007	0.008	0.006	0.007	0.006	0.006	0.005	0.005
		Plastics	Gg-CH_4	0.03	0.05	0.05	0.01	0.01	0.01	0.01	0.01	0.01
		Other (biogenic)	Gg-CH_4	0.14	0.21	0.18	0.54	0.42	0.38	0.33	0.33	0.28
	Specially controlled waste	Waste oil	Gg-CH_4	0.001	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002
		Infectious plastics	Gg-CH_4	0.002	0.004	0.005	0.001	0.002	0.001	0.001	0.001	0.001
		Infectious waste (except plastics; biogenic)	Gg-CH_4	0.002	0.004	0.005	0.051	0.058	0.042	0.048	0.044	0.043
	Total		Gg-CH_4	0.64	0.71	0.63	0.68	0.56	0.50	0.46	0.46	0.40
			Gg-CO_2 eq	13.481	14.868	13.333	14.267	11.817	10.495	9.691	9.623	8.417
N_2O	Municipal solid waste		Gg-N_2O	1.03	1.05	0.98	0.52	0.47	0.48	0.46	0.49	0.50
	Industrial solid waste	Waste oil	Gg-N_2O	0.02	0.02	0.02	0.10	0.11	0.09	0.09	0.08	0.08
		Plastics	Gg-N_2O	0.15	0.32	0.31	0.02	0.03	0.02	0.02	0.02	0.02
		Other (biogenic)	Gg-N_2O	3.61	4.98	5.88	5.89	4.80	4.63	4.46	4.48	4.60
	Specially controlled waste	Waste oil	Gg-N_2O	0.003	0.005	0.007	0.03	0.04	0.03	0.03	0.03	0.03
		Infectious plastics	Gg-N_2O	0.01	0.02	0.03	0.003	0.003	0.002	0.002	0.002	0.002
		Infectious waste (except plastics; biogenic)	Gg-N_2O	0.002	0.004	0.005	0.02	0.02	0.01	0.02	0.01	0.01
	Total		Gg-N_2O	4.816	6.392	7.231	6.588	5.464	5.269	5.088	5.114	5.251
			Gg-CO_2 eq	1,493	1,981	2,242	2,042	1,694	1,633	1,577	1,585	1,628
	Total of all gases		Gg-CO_2 eq	13,769	17,863	19,093	16,041	16,311	13,566	14,039	13,551	13,636

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 Revised 1996 IPCC Guidelines; instead it is estimated as a reference value and reported under " Biogenic" in Table 6.A,C of the CRF.

For reference, the greenhouse gas emissions from waste incineration for energy purpose and with energy recovery are shown in Table 8-39. In FY2012, the emissions from waste incineration including these sources are 28,068 Gg-CO_2, and it accounts for 2.1% of Japan's total greenhouse gas emissions (excluding

LULUCF). The emissions from this sources category had increased by 20.4% compared to those in FY1990.

Table 8-40 Total GHG emissions from incineration of waste (reference value) including emissions from waste incineration for energy use and energy recovery

Gas	Incineration type	Waste category	Estimation Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	Waste incineration without energy recovery (simple incineration)			Gg-CO_2	12,263	15,867	16,838	13,984	14,606	11,922	12,452	11,956	12,000
	Waste incineration with energy recovery	Municipal solid waste	Plastics	Gg-CO_2	5,857	6,309	8,188	6,611	5,499	4,638	4,225	4,507	4,711
			Synthetic textiles	Gg-CO_2	585	676	660	925	1,186	1,286	1,188	1,212	1,230
			Other (biogenic)	Gg-CO_2									
		Industrial solid waste	Waste oil	Gg-CO_2	21	30	28	108	100	81	87	79	79
			Plastics	Gg-CO_2	31	65	187	306	508	369	419	381	375
			Other (biogenic)	Gg-CO_2									
	Direct use of waste as fuel	Municipal solid waste	Plastics	Gg-CO_2	NO	NO	91	507	367	409	451	431	461
		Industrial solid waste	Waste oil	Gg-CO_2	2,019	2,504	2,345	3,602	3,232	3,018	3,293	3,304	3,216
			Plastics	Gg-CO_2	54	36	446	1,203	1,325	1,418	1,467	1,492	1,520
			Waste wood	Gg-CO_2									
		Waste tire	Fossil origin	Gg-CO_2	524	841	1,039	865	1,023	946	1,003	971	946
			Biogenic origin	Gg-CO_2									
	Use of processed waste as fuel	Refuse derived fuel (RDF, RPF)	Fossil origin	Gg-CO_2	26	41	159	997	1,363	1,395	1,379	1,435	1,475
			Biogenic origin	Gg-CO_2									
	Total			Gg-CO_2	21,379	26,369	29,980	29,108	29,209	25,484	25,963	25,767	26,012
CH_4	Waste incineration without energy recovery (simple incineration)			Gg-CH_4	0.64	0.71	0.63	0.68	0.56	0.50	0.46	0.46	0.40
	Waste incineration with energy recovery	Municipal solid waste		Gg-CH_4	0.54	0.54	0.60	0.14	0.13	0.12	0.12	0.11	0.12
		Industrial solid waste	Waste oil	Gg-CH_4	0.00004	0.00005	0.00005	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
			Plastics	Gg-CH_4	0.0004	0.0008	0.002	0.0010	0.002	0.001	0.001	0.001	0.001
			Other (biogenic)	Gg-CH_4	0.0004	0.001	0.001	0.008	0.02	0.01	0.01	0.01	0.01
	Direct use of waste as fuel	Municipal solid waste	Plastics	Gg-CH_4	NO	NO	0.00003	0.00005	0.00002	0.00005	0.00001	NO	NO
		Industrial solid waste	Waste oil	Gg-CH_4	0.01	0.02	0.02	0.03	0.02	0.02	0.03	0.03	0.03
			Plastics	Gg-CH_4	0.0002	0.0002	0.04	0.12	0.16	0.17	0.16	0.17	0.17
			Waste wood	Gg-CH_4	1.76	1.76	2.22	2.89	4.01	4.22	4.20	4.37	3.54
		Waste tire		Gg-CH_4	0.03	0.08	0.10	0.08	0.06	0.05	0.04	0.04	0.03
	Use of processed waste as fuel	Refuse derived fuel (RDF, RPF)		Gg-CH_4	0.00008	0.0001	0.0006	0.006	0.01	0.01	0.01	0.01	0.01
	Total			Gg-CH_4	2.98	3.10	3.61	3.94	4.98	5.10	5.03	5.20	4.30
				Gg-CO_2 eq	63	65	76	83	105	107	106	109	90
N_2O	Waste incineration without energy recovery (simple incineration)			Gg-N_2O	4.82	6.39	7.23	6.59	5.46	5.27	5.09	5.11	5.25
	Waste incineration with energy recovery	Municipal solid waste		Gg-N_2O	1.19	1.32	1.53	1.13	1.02	0.95	0.93	0.91	0.94
		Industrial solid waste	Waste oil	Gg-N_2O	0.00009	0.0001	0.0001	0.002	0.002	0.002	0.002	0.002	0.002
			Plastics	Gg-N_2O	0.002	0.005	0.01	0.002	0.003	0.002	0.002	0.002	0.002
			Other (biogenic)	Gg-N_2O	0.008	0.009	0.01	0.005	0.007	0.006	0.006	0.006	0.005
	Direct use of waste as fuel	Municipal solid waste	Plastics	Gg-N_2O	NO	NO	0.00002	0.00004	0.00001	0.00004	0.00001	NO	NO
		Industrial solid waste	Waste oil	Gg-N_2O	0.02	0.02	0.03	0.04	0.04	0.04	0.04	0.04	0.04
			Plastics	Gg-N_2O	0.0002	0.0001	0.004	0.01	0.01	0.01	0.01	0.01	0.01
			Waste wood	Gg-N_2O	0.02	0.02	0.03	0.03	0.05	0.05	0.05	0.05	0.04
		Waste tire		Gg-N_2O	0.005	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
	Use of processed waste as fuel	Refuse derived fuel (RDF, RPF)		Gg-N_2O	0.0005	0.0008	0.003	0.02	0.03	0.03	0.03	0.03	0.03
	Total			Gg-N_2O	6.06	7.78	8.86	7.85	6.64	6.37	6.18	6.19	6.34
				Gg-CO_2 eq	1,878	2,410	2,748	2,434	2,059	1,974	1,914	1,918	1,965
Total of all gases				Gg-CO_2 eq	23,320	28,845	32,804	31,625	31,372	27,565	27,983	27,794	28,068

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 Revised 1996 IPCC Guidelines

8.4.1. Waste Incineration without Energy Recovery (6.C.)

8.4.1.1. Municipal Solid Waste Incineration (6.C.1)

a） ***Source/Sink Category Description***

This category covers the emissions from incineration of MSW without energy recovery. Emissions of CO_2 are reported under either “biogenic” or “plastics and other non-biogenic waste” in accordance with the waste type. Emissions of CH_4 and N_2O are estimated for each type of furnace. The data used for MSW incineration can not distinguish wastes that are either biogenic-origin or non-biogenic origin. Therefore, total emissions including biogenic-origin ones are reported altogether under “plastics and other non-biogenic 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 GPG (2000) (Page 5.26, Fig. 5.5). In order to estimate CO_2 emissions from the incineration of fossil-fuel derived waste[3], emissions from plastics and synthetic textile in municipal waste are calculated.

$$E = EF \times A \times (1-R)$$

E : Emission of carbon dioxide from the incineration of various types of waste [kg-CO_2]
EF : Emission factor for the incineration of various types of waste (dry basis) [kg-CO_2/t]
A : Volume of each type of waste incinerated (dry basis) [t]
R : Percentage of municipal solid waste incinerated at facilities with energy recovery

- ***Emission Factor***

In accordance with the *Revised 1996 IPCC Guidelines*, the emission factor is calculated by multiplying the carbon content of each type of waste by the incineration rate at each incinerator.

CO_2 Emission factor (dry basis)

= 1000 [kg] × Carbon content × efficiency of combustion × 44/12

➢ ***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, according to the Survey Study on Improving the Accuracy of Emission Factors for Greenhouse Gas Emissions from the Waste Sector, 2010, Ministry of the Environment (Reference #15).

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.

Table 8-41 Carbon content of plastics and synthetic textile in MSW (dry bases)

Item	Carbon content	Remarks
Plastics	75.1 %	Averaged value of the data provided by four municipalities
Plastic bottle	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

[3] Emissions from the incineration of kitchen garbage, waste paper, waste natural fiber textiles and waste wood, and biomass-based plastics are accounted for as the reference figures of biogenic waste. Estimation methods for their emissions are the same as those for emissions from the incineration of fossil-fuel derived plastics and synthetic textile.

➢ *Efficiency of Combustion*

Taking into account Japan's circumstances, the default value of 99% indicated in the *GPG (2000)* is used.

Table 8-42 Emission factors for plastics and synthetic textile in MSW (dry bases)

Item	Unit	Emission factor
Plastics	kg-CO_2/t	2,726
Synthetic textile	kg-CO_2/t	2,287

Table 8-43(Reference value) Emission factor for plastic bottle (dry bases)

Item	Unit	Emission factor	Remarks
Plastic bottle	kg-CO_2/t	2,269	Not adopted to estimate CO_2 emissions

- ***Activity Data***

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 plastics incinerated (wet basis) and also subtracting the amount of biomass-based plastics incinerated (dry basis) in MSW which are estimated separately.

<u>*Activity data for plastics (MSW) incinerated (dry basis)*</u>
= Volume of plastics incinerated (wet basis)
× (1 - Percentage of water content in plastics)
– Amount of biomass-based plastics incinerated (dry basis)

The activity data of waste 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 texitile, and subtracing the water content in textiles.

<u>*Activity data for incineration of synthetic textile (MSW) (dry basis)*</u>
= Volume of textile incinerated (wet basis)
× (1 - Percentage of water content in textiles)
× Percentage of synthetic fiber content in textiles

Table 8-44 Amount of incineration of plastics and synthetic textile in MSW (dry basis)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Plastics	kt / year (dry)	3,998	4,160	4,919	3,548	2,960	2,582	2,326	2,548	2,665
Synthetic textile	kt / year (dry)	476	531	473	592	759	850	776	813	825

➢ *Incineration Volume by Type of Municipal Solid Waste*

The amount of plastics including biomass-based plastics and textiles incinerated are obtained from the *Cyclical Use of Wastes Report*.

➢ *Amount of Incinerated Biomass-based Plastics (Municipal Solid Waste)*

The amount of biomass-based plastics contained in plastics (MSW) incinerated is estimated as the equation indicated below.

$$WBP_I = \Sigma(BP_i \times Org_i \times Dom_i \times DM_{i,j}) \times PI_{MSW}$$

WBP_I : Amount of biomass-based plastics contained in plastics (MSW) incinerated (dry base) [t]
$BP_{i,}$: Amount of biomass-based plastics type *i* produced in a reporting year [t]
Org_i : Fraction of biogenic component of biomass-based plastics type *i*
Dom_i : Fraction of biomass-based plastics type *i*, produced, distributed, used, and disposed of in the country
$DM_{i,j}$: Fraction of biomass-based plastics type *i* for the use *j* to be disposed of as MSW
PI_{MSW} : Fraction of plastics (MSW) incinerated

- *Amount of Biomass-based Plastics Produced by Type and Use* (Bp_i)

The amount of biomass-based plastics produced by type (e.g. PLA, starch, cellulose, etc.) and use (e.g. food container, cushioning material, LCD, etc.) is obtained from the survey conducted by the Japan Society of Biomass Industries. The time from the use to disposal of biomass-based plastic products by type and use is also determined on the basis of survey conducted by the Japan Society of Biomass Industries.

In principle, the time from the use to disposal of durable consumer biomass-based plastic products by type and use (service life) is determined as one year. The service lives for non-durable consumer biomass-based plastic products are determined based on the survey conducted by the Japan Society of Biomass Industries. Where the service life is one year, it is assumed that the production and disposal of the products takes place in the same year in order to estimate the amount of biomass-based plastic products disposed of.

$$BP_{i,N} = \sum_j \left(bp_{i,j,(N-\alpha(i,j))} \right)$$

$BP_{i,N}$: Amount of biomass-based plastics type *i* disposed of in year N [t]
$bp_{i,j,N}$: Amount of biomass-based plastics type *i* for the use of *j* produced in year *N* [t]
$\alpha(i,j)$: Time from the use to disposal of biomass-based plastic product type *i* for the use of *j* [year]

- *Fraction of Biogenic Component of Biomass-based Plastics by Type and Use* (Org_i)

Fraction of biogenic component of biomass-based plastics by type and use is deteremined on the basis of research results conducted by the Japan Society of Biomass Industries.

- *Fraction of Biomass-based Plastics by Type and* Use *Produced, Distributed, Used, and Disposed of in the Country* (Dom_i)

Due to the fact that most of biomass-based plastics distributed in the country are made of imported biomass-based plastics used as a raw material, in principle, the fraction of biomass-based plastics by type and use that is distributed, used, and disposed of in the country is established for 1.0.

However, for some of the products to be exported abroad, the said fraction is established on the basis of survey results conducted by the Japan Society of Biomass Industries.

- *Fraction of Biomass-based Plastics Type i for the Use j to be Disposed of as MSW (DMi,j)*

All the biomass-based plastics products after use are considered to be disposed of. An individual fraction of biomass-based plastics to be disposed of for MSW and ISW is established respectively on the basis of expert judgment because actual data are unavailable.

- *Fraction of Plastics (MSW) Incinerated (PI_{MSW})*

  Biomass-based plastics disposed of are treated in various ways. The fraction of biomass-based plastics incinerated, used as raw materials or fuels, and used as RDF are estimated by dividing the amount of biomass-based plastics incinerated (Reference #10), used as raw materials or fuels, and plastic-derived content contained in RDF by the amount of plastics disposed of as MSW.

Table 8-45 (Reference) Total amount of biomass-based plastics production (dry basis)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Total amount of biomass-based plastics production	t / year (dry)	-	-	-	-	45,024	58,624	62,596	57,488	57,170

Source: Reference #50

Table 8-46 Fraction of plastics (MSW) incinerated, used as raw materials and fuels, and used as RDF

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
For incineration	%	74.9	79.5	86.7	79.4	77.6	75.3	73.1	79.8	83.8
For direct use of waste as fuel	%	0	0	0.6	5.3	4.5	5.6	6.9	6.6	6.9
For RDF	%	0.2	0.2	0.8	2.8	2.9	3.2	3.6	3.5	3.5

Source: Reference #10

Note: The rest of municipal waste other than the above are recycled or landfilled.

➢ ***Percentage of Water Content***

The percentage of water content in plastics in MSW is determined to be 20% provided by the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*. The percentage of water content in the textiles contained in MSW is determined to be 20% based on expert judgment and their review of case studies in Japan.

➢ ***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 8-47 Percentage of synthetic textile in textiles

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Fraction of Synthetic textile	%	49.1	50.7	53.5	52.8	55.9	56.6	59.6	63.2	64.1

➢ ***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 8-48 Percentage of municipal solid waste incinerated at incineration facilities with energy recovery

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Without off-field power generation or heat utilization	%	46.3	44.4	38.9	31.6	31.6	33.9	33.1	34.8	34.8
With off-field power generation or heat utilization	%	53.7	55.6	61.1	68.4	68.4	66.1	66.9	65.2	65.2

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.

$$E = \sum \left(EF_i \times A_i\right) \times \left(1 - R\right)$$

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 #15). Therefore, based on the survey (Reference #15) 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 #15), 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.

Table 8-49 CH_4 emission factors by incineration method of incinerator (MSW)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Continuous incinerator	g-CH_4/t	8.2	8.2	8.3	2.6	2.6	2.6	2.7	2.7	2.7
Semi-continuous incinerator	g-CH_4/t	69.6	69.6	75.1	19.9	21.0	20.6	20.9	20.8	20.8
Batch type incinerator	g-CH_4/t	80.5	80.5	84.1	13.2	13.2	13.4	11.6	11.6	11.6

Source: Reference #6, 8, 15, 27, 49, 55

➢ ***Gasification Melting Furnace***

Different emission factor is used for each furnace type (shaft furnace, fluidized bed, and rotary kiln) (Reference #15). 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 8-50 CH_4 emission factors by type of gasification melting furnace (MSW)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasification melting furnace	g-CH_4/t	-	-	5.6	6.9	7.1	7.0	7.0	7.0	7.0

- ***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 *Report of the Research on the state of wide-range Movement and Cyclical Use of Wastes*(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 8-51 Amount of incineration of MSW by type of incinerator

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Continuous incinerator	kt /year (wet)	26,215	29,716	32,749	32,246	29,426	28,444	27,603	27,892	28,669
Semi-Continuous Incinerator	kt /year (wet)	4,810	5,455	5,882	4,047	3,339	3,155	2,968	2,932	3,014
Batch type Incinerator	kt /year (wet)	5,643	4,328	3,131	1,562	1,346	1,144	1,078	1,057	1,087

Table 8-52 Amount of incineration of MSW from gasification melting furnace

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasification melting furnace	kt /year (wet)	0	0	370	2,397	3,122	3,245	3,605	3,857	3,965

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.

$$E = \sum (EF_i \times A_i) \times (1 - R)$$

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 #15), 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*.

Table 8-53 N_2O emission factors for incinerator by incineration method (MSW)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Continuous incinerator	g-N_2O/t	58.8	58.8	59.1	37.9	37.9	37.9	38.0	38.0	38.0
Semi-continuous incinerator	g-N_2O/t	56.8	56.8	57.3	71.5	73.3	72.7	73.2	73.1	73.1
Batch type Incinerator	g-N_2O/t	71.4	71.4	74.8	76.0	76.0	76.0	76.2	76.2	76.2

Source: Reference #7, 8, 15, 27, 49, 55

- ***Gasification Melting Furnace***

Different emission factor is used for each furnace type (shaft furnace, fluidized bed, and rotary kiln) (Reference #15). 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 8-54 N_2O emission factors for gasification meting furnace (MSW)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasification melting furnace	g-N_2O/t	-	-	16.9	12.0	11.1	11.2	11.5	11.9	11.9

- ***Activity Data***

The activity data for estimating CH_4 emissions from incinerator and gasification melting furnace are also applied for the activity data for N_2O emission estimates from incinerator and gasification melting furnace.

c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of uncertainty in the CO_2 emission factor is estimated by using the uncertainties in the carbon content of MSW (plastic and synthetic textile) and the incineration rate of MSW incineration facilities. The uncertainty in activity data for CO_2 emissions is estimated from the uncertainties in the amount of MSW incinerated, the percentage of water content and the percentage of synthetic textile (for synthetic textile in MSW).

The uncertainties in the CH_4 and N_2O emission factors are evaluated by type of incineration facilities and determined from the uncertainties in the emission factors for each type of incineration facilities and the ratio of the incinerated amount by type of incineration facilities. The uncertainties in the activity data are estimated based on the uncertainties in the amount of waste incinerated and the ratio of incinerated amount by type of incineration facilities. The methods of evaluation of the uncertainty levels for each component are:

- Use of 95% confidence interval: carbon content, fraction of synthetic textile, emission factors for CH_4 and N_2O by type of incineration facility
- Use of the default value in the 2006 IPCC Guidelines: combustion rate
- Based on expert judgment: percentage of water content

- Use of the statistical uncertainties: incinerated amount of waste and incineration rate by incinerator type

The uncertainties in the CO_2 emissions from incineration of plastics and synthetic textiles of MSW are estimated to be 17% and 23%, respectively. The uncertainties in the CH_4 and N_2O emissions from incineration of MSW are estimated to be 101% and 42%, respectively. For more details, see the Annex 7.

- ***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） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

- Updating the data on the amount of municiple waste incinerated for the period FY2007-2011, emission estimates for the said fiscal years were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector.”

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4.1.2. Industrial Waste Incineration (6.C.2)

a） ***Source/Sink Category Description***

This category covers CO_2, CH_4 and N_2O emissions from incineration of ISW without energy recovery by each waste type and the emissions are reported in the corresponding category either “biogenic” or “plastics and other non-biogenic waste”.

b） ***Methodological Issues***

1） ***CO_2***

- ***Estimation Method***

Emissions of CO_2 from this source are calculated by using the volume of waste fossil-fuel derived oil and plastics incinerated, Japan’s country-specific emission factors, and the percentage of incinerated industrial solid waste with energy recovery at industrial waste incineration facilities in accordance with the decision tree of the *GPG (2000)* (Page 5.26, Fig. 5.5). 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.

$E = EF \times A \times (1-R)$

E : Emission of carbon dioxide from incineration of waste [kg-CO_2]

EF : Emission factor for waste incineration (wet basis) [kg-CO_2/t]

A : Amount of waste incinerated (wet basis) [t]

R : Percentage of industrial solid waste incinerated at facilities with energy recovery (by type of waste)

- ***Emission Factor***

In accordance with the approach taken by the *Revised 1996 IPCC Guidelines*, emission factor was calculated by multiplying the carbon content of each type of waste by the incineration rate for incineration facilities.

Carbon dioxide emission factor (wet basis)

= 1000 [kg] × Carbon content × Efficiency of combustion × 44/12

➢ ***Carbon Content***

Carbon content in waste oil was deemed to be 80% based on the factor of 0.8 [t-C/t] given in the *Environmental Agency's Report on a Survey of Carbon Dioxide Emissions (1992)* (Reference #5).

Carbon content in plastics was deemed to be 70% based on the factor of 0.7 [t-C/t] given in the said report .

Table 8-55Emission factors for plastics and synthetic textile in MSW (wet bases)

Item	Carbon contents	References
Waste oil	80%	Reference #5
Plastics	70%	Reference #5

➢ ***Efficiency of Combustion***

Considering Japan's circumstances, the default value for hazardous wastes of 99.5% given in the *GPG (2000)* is used.

Table 8-56Emission factors of plastics and synthetic textile in MSW (wet bases)

Item	Unit	Emission factor
Waste oil	kg-CO_2/t	2,554
Plastics	kg-CO_2/t	2,919

- ***Activity Data***

For the activity data for CO_2 emissions from the incineration of waste oil and plastics in industrial waste, the amount of incineration provided by *the Report of the Research on the State of Wide-range Movement and Cyclic Use of Wastes* was 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 (6.C.3)", thus it is subtracted from the activity data from this source. The activity data for waste fossil-fuel derived oil is obtained by using the fraction of animal and vegetable waste oil (biogenic-origin waste oil) provided by the survey study conducted by the Ministry of the Environment from the total amount of waste oil (see the methodological equation indicated below). Activity data for industrial plastics are estimated by subtracting the activity data for biomass-based plastics (dry base) from the activity data for industrial plastics.

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*
*: All the waste oil in specially controlled industrial waste to be estimated for emissions are waste fossil-fuel derived oil.

Activity data for the incineration of waste oil and plastics (ISW) (wet basis)
= Amount of plastics incinerated in industrial waste
– Amount of plastics incinerated in specially controlled industrial waste
– Amount of industrial waste biomass-based plastics incinerated (wet base)

Table 8-57 Incinerated ISW (waste oil and plastics)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste fossil-fuel derived oil	kt / year (wet)	1,258	1,498	1,646	1,493	1,622	1,314	1,408	1,284	1,282
Plastics	kt / year (wet)	842	1,794	1,780	1,808	2,056	1,493	1,698	1,542	1,516

Table 8-58 Fraction of waste animal and vegetable oil

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Fraction of waste animal and vegetable oil	%	2.6	3.5	4.5	5.4	6.0	6.0	6.0	6.0	6.0

➢ ***Amount of Incinerated Biomass-based Plastics (Industrial Solid Waste)***

The amount of biomass-based plastics contained in industrial plastics incinerated (dry base) is estimated in the same way as indicated in “8.4.1.1. Municipal Solid Waste Incineration (6.C.1) b）1）CO_2” and converted into the value in wet base with the fraction of water content contained in industrial plastics used for RPF production (set to 5% based on expert judgment).

Table 8-59 Fraction of plastics (ISW) incinerated, used as raw materials and fuels, and RPF use

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
For incineration	%	21.2	30.7	33.6	32.7	34.9	28.8	30.0	29.5	29.8
For direct use of waste as fuel	%	0.5	0.2	3.0	7.8	8.1	9.8	9.3	10.2	10.7
For RPF	%	0	0.1	0.3	4.1	6.0	7.1	6.4	7.3	7.8

- ***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 8-60 Percentage of ISW incinerated at incineration facilities with energy recovery

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste oil [a)]	%	0.6	0.7	0.6	2.5	2.1	2.1	2.1	2.1	2.1
Plastics	%	1.4	1.4	4.1	6.6	9.7	9.7	9.7	9.7	9.7
Wood [b)]	%	0.2	0.8	1.1	1.5	4.0	4.0	4.0	4.0	4.0
Sludge	%	0.9	0.8	1.0	1.1	0.8	0.8	0.8	0.8	0.8
Other [c)]	%	0.2	0.8	1.1	1.5	0.9	0.9	0.9	0.9	0.9

Note:

a) “Waste oil” includes waste fossil-fuel derived/animal and vegetable oil.

b) “Wood” includes paper/ cardboard and wood.

c) “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 solid waste incinerated at incineration facilities with energy recovery.

$$E = \sum \left\{ EF_j \times A_j \times \left(1 - R_j\right) \right\}$$

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 solid 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 #15), 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 #15 is substituted for the emission factor for textiles (natural fiber), and animal and vegetable residues/animal carcasses.

Table 8-61 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

Source: Reference # 6, 7, 15, 28, 49

- ***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 *Report of the Research on the State of Wide-range Movement and Cyclical Use of Waste*. 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 *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*, 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 Plastics***

The activity data for waste oil and plastics are provided by the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Waste.* 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 (6.C.3), 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.

Table 8-62 Incinerated ISW by waste types

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste animal and vetable oil	kt / year (wet)	40	69	103	115	139	113	121	110	110
Paper/cardboad	kt / year (wet)	335	712	718	323	325	208	184	151	135
Wood	kt / year (wet)	2,679	4,744	3,114	1,865	1,313	1,283	1,101	1,135	879
Textiles (natural fiber)	kt / year (wet)	31	49	50	43	33	26	24	26	22
Animal and vegetable residues/animal carcasses	kt / year (wet)	77	125	272	167	220	181	190	184	183
Sludge	kt / year (wet)	5,032	5,850	6,371	7,275	6,820	6,766	6,634	6,715	7,692

Note: For the amount of waste fossil-fuel derived oil and plastics incinerated, see Table 8-56.

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 solid 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 8-63 (Reference #7).

Table 8-63 N_2O emission factors for sewage sludge incineration (wet basis)[a]

<table>
<tr><th>Type of flocculant</th><th>Type of incinerator</th><th>Combustion Temperature</th><th>Emission factor [g-N₂O/t]</th></tr>
<tr><td rowspan="3">High-molecular weight flocculant</td><td>Fluidized Bed Incinerator</td><td>Normal temperature combustion (around 800˚C)</td><td>1,508</td></tr>
<tr><td>Fluidized Bed Incinerator[b]</td><td>High temperature combustion (around 850˚C)</td><td>645</td></tr>
<tr><td>Multiple Hearth</td><td>—</td><td rowspan="2">882</td></tr>
<tr><td>Other</td><td>—</td><td>—</td></tr>
<tr><td>Lime Sludge</td><td>—</td><td>—</td><td>294</td></tr>
<tr><td>—</td><td>- Multiple hearth air injection incineration method fluidized bed incinerator
- Two-stage incineration method circulating fluidized bed incinerator
- Stoker furnace</td><td>High temperature combustion (around 850˚C)</td><td>263</td></tr>
</table>

Source: Reference #16, 30, 31, 32, 32, 56, 57, 63, 64

Note:

a) The same emission factors are used for all the reporting years.

b) 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 #15), 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 #15.

Table 8-64 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, 15, 28, 49, 56, 61, 62, 63, 64, 69, 70

- ***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 8-65 Amount of sewage sludge incinerated

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
High-molecular-weight flocculant Fluidized bed incinerator (nomal temp.)	kt / year (wet)	1,112	1,869	2,397	2,839	1,785	1,664	1,535	1,532	1,552
High-molecular-weight flocculant Fluidized bed incinerator (high temp.)	kt / year (wet)	128	219	723	1,469	2,470	2,508	2,581	2,587	2,641
High-molecular-weight flocculant multiple hearth	kt / year (wet)	560	656	572	102	56	64	61	52	43
Lime sludge	kt / year (wet)	1,010	663	272	289	193	142	109	83	74
Other	kt / year (wet)	55	161	175	8	1	1	1	3	0
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	233	282	338	439	444

➢ ***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 the CO_2 emission factor and activity data for waste oil and plastics are evaluated by the same method as is used for incineration of MSW. The uncertainties in CH_4 and N_2O emission factors are estimated by using the 95% confidence interval of actual measurement data of the emission factors by type of ISW and by type of incineration facility. The uncertainties in the CH_4 and N_2O activity data are estimated by using the statistical uncertainties for incinerated amount of industrial waste by type of waste.

The uncertainties in the CH_4 and N_2O emissions from incineration of industrial waste are estimated to be 150% and 116%, respectively. The uncertainties in the CO_2 emissions from incineration of waste oil and plastics are 105% and 100%, respectively. For more details, see the Annex 7.

● ***Time-series Consistency***

Emissions are calculated in a consistent manner.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

- Updating the data on the amount of industrial waste incinerated for FY2010 and 2011, emission estimates for the said fiscal years were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector.”

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4.1.3. Incineration of Specially controlled Industrial Waste (6.C.3)

a） ***Source/Sink Category Description***

The specially controlled industrial waste includes wastes with properties that may be harmful to human health and living environment such as explosiveness, toxicity and infectivity. This category covers 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 “biogenic” or “plastics and other non-biogenic waste”.

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 6.C.)”.

b) ***Methodological Issues***

1) ***CO_2***

- ***Estimation Method***

Emissions of CO_2 from the incineration of waste oil and infectious plastic waste contained in specially controlled industrial waste are calculated in accordance with the decision tree given in the *GPG (2000)* (Page 5.26, Fig 5.5) by using Japan's country-specific emission factors and the volume of waste incinerated.

- ***Emission Factor***

Emission factors for waste oil and plastics in industrial waste are used as the ones for waste oil and plastics in specially controlled industrial waste, since their differences in terms of carbon contents and rates of combustion are considered to be small.

- ***Activity Data***

On the assumption that the entire volume of waste oil and infectious plastic waste contained in specially controlled industrial waste is incinerated, 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 as activity data for the waste fossil-fuel derived oil; while for the plastics in infectious waste, the activity data is calculated by multiplying the output volume of infectious waste reported by the same survey by the percentage of plastic content in infectious waste indicated in the *Waste Handbook* as the result of a composition analysis of infectious waste. All the waste oil in specially controlled industrial waste to be estimated for emissions is waste fossil-fuel derived oil. All of plastics in infectious waste are considered to be fossil-fuel derived.

Activity data for incineration of waste fossil-fuel derived oil (specially controlled ISW) (wet basis)
= Output volume of waste oil

Activity data for incineration of plastics in infectious waste (specially controlled ISW)(wet basis)
= Output volume of infectious waste × 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 waste fossil-fuel derived 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***

Activity data for the waste oil and infectious plastics are the same as those used for CO_2 emission. The volume of non-infectious plastics incinerated was deemed to be the same as the output volume, and calculated by multiplying the output volume of infectious waste by the percentage of non-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 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 8-66 Amount of incineration of specially controlled industrial waste

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste fossil-fuel derived oil	kt (wet)	256	380	560	515	564	457	490	447	446
Infections Waste (plastic)	kt (wet)	78	128	167	169	193	140	159	145	142
Infections Waste (non-plastic)	kt (wet)	105	172	225	228	260	189	214	195	192

c） ***Uncertainties and Time-series Consistency***

- ***Uncertainties***

Since the same CO_2, $CH_{4,}$ and N_2O emission factors used for the industrial waste are used; their uncertainties are also applied. The uncertainties in activity data are set out separately for waste oil and plastics. To the incinerated amount of waste oil and infectious waste, twice the statistical uncertainties are applied by taking into account the fact that the data are recently obtained based on the estimation. For plastics, the uncertainties in the percentage of plastics in infectious waste are determined based on the expert judgment, and then their uncertainties are combined with the ones in the amount of waste incinerated. The uncertainties in the CO_2, $CH_{4,}$ and N_2O emissions from incineration of specially controlled industrial waste are estimated to be 167%, 142% and 159%, respectively. For details, see the Annex 7.

- ***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） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

Updating the amount of specially controlled industrial waste incinerated for FY2011, emission estimates for the said fiscal year were recalculated.

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4.2. Emissions from Waste Incineration with Energy Recovery (1.A.)

a） ***Source 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 “Power Generation/Heat Supply (Category 1.A.1.a)” and the fuel type is classified as “Other fuels”.

b） ***Methodological Issues***

Methodologies similar to that used in “8.4.1.1 Municipal Solid Waste Incineration (6.C.1)” and “8.4.1.2. Industrial Waste Incineration (6.C.2)” are used. Emissions are calculated using the following equation:

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 Solid 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 solid waste incinerated at ISW incineration facilities with energy recovery (by waste type)

2） ***CH_4 , N_2O***

- ***Estimation Method***

➢ ***Municipal Solid Waste***

$$E = \sum \left(EF_i \times A_i \right) \times R$$

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 Solid Waste***

$$E = \sum \left(EF_j \times A_j \times R_j \right)$$

E	: Emissions of CH_4 or N_2O from incineration of industrial solid waste [kg-CH_4] (kg-N_2O)
EF_j	: Emission factor for industrial solid waste type *j* (wet basis) [kg-CH_4/t], [kg-N_2O/t]
A_j	: Amount of industrial solid waste type *j* incinerated (wet basis) [t]
R_j	: Fraction of industrial solid waste type *j* incinerated at ISW 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)]
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 Solid Waste***

$$A_E = \sum A_j \times GCV_j \times R / 10^6$$

A_E	: Calorific value of activity data of ISW [TJ]
A_j	: Amount of ISW type *j* incinerated [kg (wet)]
GCV_j	: Gross calorific value of ISW type *j* [MJ/kg]
R	: Fraction of ISW type *j* incinerated at ISW incineration facility with energy recovery

Calorific value of ISW is indicated in Table 8-73 (as referred to hereinafter).

c） ***Uncertainties and Time-series Consistency***

Methodologies similar to that used in “8.4.1.1 Municipal Solid Waste Incineration (6.C.1)” and “8.4.1.2. Industrial Waste Incineration of (6.C.2)” are used.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e） ***Source-specific Recalculations***

Updating the activity data for the period FY2007-2011, the emission estimates for the said fiscal years were recalculated. For detail, see the paragraphs for source-specific recalculations on “8.4.1.1. Municipal Solid Waste Incineration (6.C.1)” and “8.4.1.2. Industrial Waste Incineration (6.C.2)”.

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4.3. Emissions from Direct Use of Waste as Fuel (1.A.)

a） ***Source/Sink 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 Industry (Category 1.A.1.)” or “Manufacturing and Construction (1.A.2)”. The fuel type is classified as “Other fuels”.

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 that used as fuel are combined and expressed as “Raw Material/Fuel Use” in this section.

Table 8-67 Estimation category for emissions from the direct use of waste as fuel

Emission source	Application breakdown	Major application	Reporting category of Energy sector	
Use of municipal solid waste (plastics) as alternative fuel or raw material	Petrochemical	Fuel	1A2f	Other
	Blast furnace reducing agent	Reducing agent in blast furnace	1A2a	Iron & Steel
	Coke oven chemical feedstock	Alternative fuel or raw material in coke oven	1A1c	Manufacture of solid fuels
	Gasification	Fuel	1A2f	Other
Use of waste oil as alternative fuel or raw material	Cement burning	Cement burning	1A2f	Cement & Ceramics
	Other	Fuel	1A2f	Other
Use of industrial solid waste (plastics) as alternative fuel or raw material	Blast furnace reducing agent	Blast furnace reducing agent	1A2a	Iron & Steel
	Boiler	Fuel	1A2b	Chemicals
	Boiler	Fuel	1A2d	Pulp, paper and print
	Cement burning	Cement burning	1A2f:	Cement & Ceramics
	Boiler	Fuel	1A2f	Machinery
Use of industrial solid waste (wood) as alternative fuel or material	-	Fuel	1A2f	Other
Use of waste tire as alternative fuel or raw material	Cement burning	Cement burning	1A2f	Cement & Ceramics
	Boiler	Fuel	1A2f	Other
	Iron manufacture	Alternative fuel or raw materials in iron manufacturing	1A2a	Iron & Steel
	Gasification	Fuel in iron manufacturing	1A2a	Iron & Steel
	Metal refining	Fuel in metal refining	1A2b	Non-ferrous metals
	Tire manufacture	Fuel in tire manufacturing	1A2c	Chemicals
	Paper manufacture	Fuel in paper manufacturing	1A2d	Pulp, paper and print
	Power generation	Power generation	1A1a	Public electricity and heat production*

Note: *Since the industry category for the use of it is not identified, “1A1a” is applied.

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 “Waste Incineration without Energy Recovery (Chapter 8.4.1.)”.

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 8-68 Country-specific CO_2 emission factors for this category

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
MSW-coke oven	kg-CO_2/t(dry)	1,420	1,420	1,420	1,420	1,420	1,420	1,420	1,420	1,420
Waste tire	kg-CO_2/t(dry)	1,858	1,785	1,790	1,737	1,725	1,729	1,750	1,735	1,735

- ***Activity Data***

Details of the amount of waste used as raw material or alternative fuels, see the 8.4.3.1. - 8.4.3.3.

Table 8-69 Use of waste as raw materials or fuels for CO_2 emissions

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
MSW-plastics-oilification	kt (dry)	0	0	3	7	3	6	1	0	0
MSW-plastics-reducer in blast furnace	kt (dry)	0	0	24	35	17	26	26	25	25
MSW-plastics-chemical material in coke-oven	kt (dry)	0	0	10	168	136	143	169	162	162
MSW-plastics-gasification	kt (dry)	0	0	1	56	45	43	51	49	59
ISW-plastics (iron and steel)	kt (wet)	0	0	57	160	74	97	137	129	149
ISW-plastics (cement)	kt (wet)	0	0	102	302	427	440	418	438	432
ISW-plastics (boiler)	kt (wet)	21	14	16	9	18	19	19	17	17
ISW-waste fossil-fuel derived oil (cement baking furnace)	kt (wet)	137	225	343	423	384	372	442	429	434
ISW-waste fossil-fuel derived oil (boiler)	kt (wet)	554	633	460	811	724	662	686	703	668
Waste tire	kt (dry)	282	471	580	498	593	547	573	560	545

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. It should be noted that emissions from some of the emission sources are not estimated. They are summarized below.

Table 8-70 CH_4 and N_2O emissions sources not included in emission estimates or allocations

Emission source	Emission source (not calculated)
Use of municipal solid waste as alternative fuel or raw materials	Blast furnace reducing agent (NO), Coke-oven chemical feedstock (IE), Gasification (NE)
Use of industrial solid waste as alternative fuel or raw materials	Blast furnace reducing agent (NO), Petrochemical (NE), Gasification (NE)
Use of waste tire as alternative fuel or raw material	Iron manufacturing (NO)

- ***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 8-71 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 8-71 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 plastics
Industrial waste	Plastics	Cement kilns	Other industrial furnaces (solid fuel)	Calorific value of plastics
		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)	Cement kilns, boilers	Other industrial furnaces (solid fuel)	Specific gravity of reclaimed oil/waste oil [a]
		Boilers	Boilers (Heavy fuel oil A, gas oil, kerosene, naphtha, other liquid fuels)	
	Wood	Boilers	CH_4: Boilers (wood, charcoal) N_2O: Boilers (other than fluidized-bed) (solid fuel)	Calorific value of wood [b]
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) [c]	

Note:

a) 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).

b) Source: 1997 General Survey of Emissions of Air Pollutants

c) 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 8-72 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 8-73 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 #25; estimated with 0.9[kg/l] from Reference #48
Plastics		MJ/kg	29.3	Reference #25
Paper/ cardboard		MJ/kg	15.1	Reference #48 (dry basis); value was obtained by subtracting water content
Wood		MJ/kg	14.4	Reference #25
Textiles		MJ/kg	17.9	Reference #48 (dry basis) ; value was obtained by subtracting water content
Food waste(Animal and vegetable residues/animal carcasses)		MJ/kg	4.4	Reference #48 (dry basis) ; value was obtained by subtracting water content
Sludge (including sewage sludge)		MJ/kg	4.7	Reference #25 (dry basis) ; value was obtained by subtracting water content
Waste tires	2004 and before	MJ/kg	20.9	Reference #25
	2005 and later	MJ/kg	33.2	Reference #25
RDF		MJ/kg	18.0	Reference #25
RPF		MJ/kg	29.3	Reference #25

- ***Activity Data***

➢ ***Waste Used as Raw Material and Fuel***

Activity data are determined for each category using the wet-basis values (Table 8-74). For more details, see each section.

Table 8-74 Amount of waste used as raw material or fuel for CH_4 and N_2O emissions

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
MSW-oilification	kt (wet)	0	0	3	7	3	7	1	0	0
ISW-waste wood	kt (wet)	1,635	1,635	2,061	2,683	3,724	3,918	3,900	4,065	3,290
ISW-waste fossil-fuel derived/animal & vegetable oil (cement baking furnace)	kt (wet)	141	233	359	447	408	396	470	456	462
ISW-waste fossil-fuel derived/animal & vegetable oil (boiler)	kt (wet)	569	657	482	858	770	704	730	748	710
Waste tire-cement baking furnace	kt (wet)	111	275	361	181	141	112	95	77	66
Waste tire-boiler	kt (wet)	119	184	163	255	394	387	428	435	433
Waste tire-pyrolysis furnace	kt (wet)	67	37	30	10	2	1	1	1	0
Waste tire-gasification	kt (wet)	0	0	0	27	48	48	49	45	45

Note: See Table 8-61 for the activity data for ISW-plastics (cement manufacturer) and ISW-plastics (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)])

× Corresponding calorific value of waste [MJ/kg]) / 10^6

c) ***Uncertainties and Time-series Consistency***

See the respective section.

d) ***Source-specific QA/QC and Verification***

See the respective section.

e） ***Source-specific Recalculations***

See the respective section.

f） ***Source-specific Planned Improvements***

See the respective section.

8.4.3.1. Emissions from Municipal Waste (Plastics) Used as Alternative Fuel (1.A.1 and 1.A.2)

a） ***Source/Sink Category Description***

This category covers the emissions from municipal waste (plastics) used as raw materials or 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.

b） ***Methodological Issues***

1） ***CO_2***

- ***Estimation Method***

Emission estimates are calculated by multiplying the amount of fossil-fuel derived plastics 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 "8.4.1.1. Municipal Solid Waste Incineration (6.C.1)" are applied. The emission factor for plastics used as chemical raw material in coke ovens was 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) was 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 amount of plastics (dry basis) was estimated by subtracting water content from the amount of plastics (wet basis). The amount of fossil-fuel derived plastics in MSW used as raw material or fuel (dry basis) was obtained by subtracting the amount of biomass-based plastics in MSW used as raw material or fuel assuming that all of the biomass-based plastics content in each usage is the same.

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)
– Amount of biomass-based plastics in MSW used as raw material or fuel (dry basis)
× Amount of MSW used as raw material or fuel by usage / amount of plastics in MSW used as raw material or fuel

Amount of biomass-based plastics in MSW used as raw material or fuel is estimated in the same way as indicated in "8.4.1.1. Municipal Solid Waste Incineration (6.C.1) b) 1) CO_2".

- ***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 was 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 was deducted.

Processing of plastics collected by municipalities

The amount of plastics in MSW collected by municipalities and processed into raw material or fuel was 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 was 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 was 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 Plastics 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 was 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% was determined based on the data provided by the *Japan Containers and Packaging Recycling Association*.

- ***Amount of Biomass Plastics Products Consumed***

See the section "Municipal Solid Waste Incineration (6.C.1)."

- ***Fraction of Biogenic Component in Biomass-based Plastics Disposed of as MSW***

See the section "Municipal Solid Waste Incineration (6.C.1)."

- ***Fraction of Plastics Used as Raw Material or Fuel***

SEe the section "Municipal Solid Waste Incineration (6.C.1)."

2） ***CH_4, N_2O***

For estimation method and emission factors, see the section "Emissions from Direct Use of Waste as Fuel (8.4.3)". The amount of plastics used as raw material or fuel by usage (wet basis) was 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 same value of uncertainty in "CO_2 emissions from incineration of MSW (6.C.1.a)" was used for the uncertainty in the CO_2 emission factor. The uncertainty in activity data for CO_2 emissions was estimated by using the uncertainties in the amount of plastics used as raw materials or alternative fuels (statistical uncertainty) and the percentage of water content (same value that was used for the MSW incineration).

The uncertainty in the CH_4 emission factor was estimated by using the uncertainties in emission factors and the calorific value of plastics. For uncertainty in CH_4 and N_2O activity data, the uncertainties in the amount of MSW plastics used as raw materials or alternative fuels are used. The uncertainties in the CO_2, CH_4 and N_2O emissions from MSW plastics used as raw materials or alternative fuels are estimated to be 17%, 180% and 112%, respectively. For details, see the Annex 7.

- ***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) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e) ***Source-specific Recalculations***

Updating the data necessary for estimating biomass-based plastics in the activity data (the amount of plastics disposed of as MSW) for FY 2010 and 2011, emission estimates for the said fiscal years were recalculated. For detail, see the section "8.1.3. General Recalculations for Emissions from Waste Sector."

f) ***Source-specific Planned Improvements***

No improvements are planned.

8.4.3.2. Emissions from Industrial Waste (Plastics, Waste Oil, and Wood) Used as Raw Material or Alternative Fuels (1.A.2.))

a) ***Source/Sink 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 plastics incinerated subtracting the amount of biomass-based plastics 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 ISW.

- ***Activity Data***

➢ ***Industrial Waste 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 was provided by the following data sources: for steel industry, the *Current State of Plastic 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 amount of biomass-based plastics contained in industrial plastics and used as raw material or fuel is estimated in the same way as indicated in "8.4.1.2. Industrial Waste Incineration (6.C.2) 8.4.1.2. b) 1) CO_2" and converted into the value in wet base with the fraction of water content contained in industrial plastics used for RPF production (set to 5% based on expert judgment).

➢ ***Waste Fossil-fuel derived Oil***

Activity data are estimated by subtracting 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 from the amount of waste oil indicated as "Fuel Usage" of "Direct Recycle Usage" and "Recycle Usage after Treatment" of ISW provided by the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*. The activity data for FY1997 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 "Emissions from Direct Use of Waste as Fuel (8.4.3)"

● ***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 raw material or fuel is calculated separately for cement kilns and boilers. The amount of waste oil and reclaimed oil, which was produced from the waste oil contained in industrial waste and other waste oil, used as fuel for cement kilns was determined from the annual data in the *Cement Handbook*. The amount used as fuel for boilers was determined by subtracting the amount used as fuel for cement kilns from the amount of waste oil indicated as "Fuel Usage" of "Direct Recycle Usage" and "Recycle Usage after Treatment" of ISW provided by the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes.*

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 was obtained from the "fuel usage" in the "direct recycle usage" and the "fuel usage" in the "recycle usage after treatment" in the *Report of the Research on the State of Wide-range Movement (the volume on Cyclical Use)*. 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 same value of uncertainty as was used for “CO_2 emissions from incineration of industrial waste (6.C.1.b)” was applied to uncertainty in CO_2 emission factor. The uncertainties in emission factors for CH_4 and N_2O are evaluated by the same method that was used for municipal waste used as raw materials or alternative fuels. The uncertainty in activity data are evaluated separately for plastics, waste oil, and wood. For plastics, the uncertainty was calculated by combining of the uncertainties in the amount of plastics used as raw materials or alternative fuels in the iron and steel industry and in the cement industry. The uncertainty levels for each component are evaluated by using the statistical uncertainties. For waste oil, the values for cement kilns (statistical uncertainty) and boilers (a value for CO_2) are combined. For wood, statistical uncertainties for the amount of wood used as raw materials or alternative fuels are used.

The uncertainties in CO_2, CH_4 and N_2O emissions from the incineration of industrial waste used as raw material or alternative fuels are estimated to be in the range of 13-105%, 74-128% and 31-110%, respectively. For details, see the Annex 7.

- ***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 was used to estimate the amount of wood for the past years. The emissions are calculated in a consistent manner.

d） *Source-specific QA/QC and Verification*

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e） *Source-specific Recalculations*

- Updating the data necessary for estimating biomass-based plastics in the activity data (the amount of plastics disposed of as MSW) for FY 2010 and 2011, emission estimates for the said fiscal years were recalculated.
- Updating the data on the amount of ISW used as raw material or alternative fuels for FY2006, 2007 and 2011, emission estimates for the said fiscal year were recalculated. For detail, see the section “8.1.3. General Recalculations for Emissions from Waste Sector.”

f） *Source-specific Planned Improvements*

No improvements are planned.

8.4.3.3. Emissions from Waste Tires Used as Raw Materials and Alternative Fuels (1.A.1 and 1.A.2)

a） ***Source/Sink Category Description***

This category includes the emissions from the use of waste tires as raw materials or 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 was calculated by multiplying the fossil fuel-derived carbon content of the waste tires by the efficiency of combustion 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 was calculated by the material contents of new tires. The efficiency of combustion for waste tires was set to 99.5% based on the maximum default value for hazardous waste in the *GPG (2000)*.

Calculation of emission factor for the incineration of waste tires (dry basis)
= (Fossil fuel-derived carbon content in waste tires)
× (Efficiency of combustion of waste tires)
× 1000 × 44 / 12

● ***Activity Data***

Activity data (dry basis) was 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 8.4.3.

● ***Activity Data***

The volume of waste tires used as raw material or fuel by usage that was determined during the calculation of the CO_2 emissions from this source was 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 level of uncertainty in CO_2 emission was estimated by using the carbon content of waste tires and the combustion rate of the furnace using waste tires as alternative fuels. For activity data, the uncertainty was estimated by using the uncertainties in the amount of waste tires used as raw materials or alternative fuels and the percentage of water contents in waste tires. The uncertainties in the emission factors for CH_4 and N_2O are evaluated by the same method that was applied to MSW used as raw materials or alternative fuels and are estimated by combining the uncertainties in emission factors (CH_4, N_2O of the Energy sector) using waste tires as raw materials or alternative fuels and in the calorific value of waste tires. For activity data, the uncertainties in the amount of waste tires used as raw materials or alternative fuels are used. The methods of evaluation of the uncertainty levels for each component are:

- Use of the values for industrial waste (plastics) incineration: carbon content and combustion rate
- Based on expert judgment: percentage of water contents
- Use of the uncertainties set by each statistics: amount of waste tires used as raw materials or alternative fuels

The uncertainties in CO_2, CH_4 and N_2O emissions from the use of waste tires as raw materials or alternative fuels are estimated to be 15%, 91% and 26%, respectively. For details, see the Annex 7.

- ***Time-series Consistency***

The emissions are calculated in a consistent manner.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e） ***Source-specific Recalculations***

No recalculations are conducted.

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.4.4. Emissions from Incineration of Waste Processed as Fuel (1.A.)

8.4.4.1. Incineration of Refuse-based Solid Fuels (RDF and RPF) (1.A.1 and 1.A.2)

a） ***Source/Sink 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 Industry (1.A.1) ” and

"Manufacturing/Construction (1.A.2)" according to the use of waste as fuels. The fuel type is classified as "Other fuels".

Table 8-75 Estimation category for emissions from the use of waste processed as fuel

Emission source	Application breakdown	Major application	Reporting category of Energy sector	
Use of refuse-derived fuel (RDF・RPF)	RDF	Fuel use (including power generation)	1A2f	Other*
	RPF (petroleum products)	boiler fuel	1A1b	Petroleum refining
	RPF (chemical industry)	boiler fuel	1A2c	Chemicals
	RPF (paper manufacture)	Fuel use in paper manufacturing	1A2d	Pulp, paper and print
	RPF (cement burning)	Cement burning	1A2f	Cement & ceramics

Note: *Emissions from power generation and heat supply excluding in-house use should be included in the category 1A1a. However, they are reported in the category 1A2f, because the actual circumstances are not understood at the moment.

b) *Methodological Issues*

1) CO_2

- ***Estimation Method***

Emissions are estimated by subtracting the amount of biomass plastics-derived CO_2 emissions included in plastics used for RDF from the emissions estimated by multiplying the amount of RDF and RPF incinerated by Japan's country-specific emission factor.

$$E_{RDF} = EF_{RDF} \times AD_{RDF} - EF_{MSW\ plastics} \times WBP_{RDF}$$

E_{RDF} : CO_2 Emissions from RDF use [kg-CO_2]
EF_{RDF} : Emission factor for RDF use (dry base) [kg-CO_2/t]
AD_{RDF} : Activity data for RDF use [kt (dry)]
$EF_{MSW\ plastics}$: Emission factor for municipal waste plastics [kg-CO_2/t (dry)]
WBP_{RDF} : Amount of biomass plastics used for RDF [t (dry)]

$$E_{RPF} = E_{RPF} \times AD_{RPF} - EF_{ISW\ plastics} \times WBP_{RPF}$$

E_{RPF} : CO_2 Emissions from RPF use [kg-CO_2]
EF_{RPF} : Emission factor for RPF use (wet base) [kg-CO_2/t]
AD_{RPF} : Activity data for RPF use [kg-CO_2/t (dry)]
$EF_{ISW\ plastics}$: Emission factor for plastics (ISW) [kg-CO_2/t (wet)]
WBP_{RPF} : Amount of biomass plastics used for RPF [t (wet)]

- ***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 base) by the fraction of carbon content contained in plastics and the combustion rate of RDF at RDF combustion facilities.

$EF_{RDF} = 1000 \times P_{RDF} \times C \times B_{RDF} / 12 \times 14$
$= 1000 \times 0.296 \times 0.762 \times 0.99 / 12 \times 44$
$= 820$ [kg-CO_2/t]

P_{RDF} : Fraction of plastic-derived content contained in RDF (dry base)
C : Fraction of carbon content contained in plastics (dry base)
B_{RDF} : Combustion rate of RDF at RDF combustion facilities

- *Fraction of Plastic-derived Content Contained in RDF (Dry Base)(* P_{RDF})
  Fraction of plastic-derived content contained in RDF in wet base (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 base with the fraction of water content of MSW (20%) applied in "Emissions from Managed Landfill Sites (6.A.1.), CH_4" as well as " Municipal Solid Waste (Plastics) Incineration (6.C.1.), CO_2".

- *Fraction of Carbon Content Contained in Plastics (Dry Base)*(C)
  Due to the fact that most of plastics contained in RDF is considered to be municipal solid waste-derived, the average fraction of carbon content used in "Emissions from Managed Landfill Sites (6.A.1.), CH_4" as well as "Municipal Solid Waste (Plastics) Incineration (6.C.1.), CO_2" as shown inTable 8-41 is applied for the fraction of carbon content contained in plastics (dry basis).

- *Combustion Rate of RDF at RDF Combustion Facilities* (B_{RDF})
  As applied in "Municipal Solid Waste (Plastics) Incineration (6.C.1.), CO_2", the maximum default value provided in *GPG (2000)* (99%) is also applied for the combustion rate of RDF at RDF combustion facilities.

➢ ***RPF***

Because the quality of RPF is categorized into "coal-equivalent product" and "coke-equivalent product"(see Reference #47), 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 Base)*" as described herein below.)

Coal-equivalent product

$EF_{RPF,coal} = 1000 \times P_{RPF,\,coal} \times C \times B_{RPF} / 12 \times 44$
$= 1000 \times 0.528 \times 0.737 \times 0.995 / 12 \times 44$
$= 1419$ [kg-CO_2/t]

Coke-equivalent product

$EF_{RPF,coke} = 1000 \times P_{RPF,coke} \times C \times B_{RPF} / 12 \times 44$
$= 1000 \times 0.910 \times 0.737 \times 0.995 / 12 \times 44$
$= 2445$ [kg-CO_2/t]

$EF_{RPF,coal}$: Emission factor for the use of coal-equivalent product RPF (dry base) [kg-CO_2/t]
$EF_{RPF,coke}$: Emission factor for the use of coke-equivalent product RPF (dry base) [kg-CO_2/t]
$P_{RPF,coal}$: Fraction of plastics-derived content contained in coal-equivalent product RPF (dry base)
$P_{RPF,coke}$: Fraction of plastics-derived content contained in coke-equivalent product RPF (dry base)
C : Fraction of carbon content contained in plastics (dry base)
B_{RPF} : Combustion Rate of RPF at RPF combustion facilities

- *Fraction of Waste Plastic-derived Content Contained in RPF (Dry Base)($P_{RPF,coal/coke}$)*
  The fraction of waste plastic-derived content contained in RPF in wet base 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 base 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 Plastics (Dry base) (C)*
  Due the fact that most of plastics contained in RDF is industrial waste-derive (see Reference #61), the fraction of carbon content contained in plastics in dry base (73.7%) is calculated with the same fraction of carbon content contained in industrial waste plastics applied in "Incineration of Industrial Waste (Plastics) (6.C.2.), CO_2" (70%) and the fraction of water content of industrial waste plastics (5%).

- *Combustion Rate of RPF at RPF Fuel Facilities (B_{RPF})*
  As applied in "Industrial Incineration (Plastics) Solid Waste (Plastics) (6.C.2.), CO_2", the maximum default value for hazardous waste provided in *GPG (2000)* (99.5%) is also applied for the combustion rate of RPF at RPF combustion facilities.

- *Emission Factor for RPF Use (Weighted Average) ($EF_{RPF,av}$) (Dry Base)*
  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 base) is obtained from the survey results conducted by Japan RPF Industry Association and is converted into the value in dry base. 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 base are applied to all the reporting years because relevant statistics is unavailable.

$$EF_{RPF,av} = EF_{RPF,coal} \times P_{coal} + EF_{RPF,coke} \times P_{coke}$$
$$= 1419 \times 0.797 + 2445 \times 0.203$$
$$= 1627 \text{ [kg-}CO_2\text{/t]}$$

$EF_{RPF,av}$: Emission factor for RPF use (Weighted Average) (dry base) [kg-CO_2/t]

P_{coal} : Fraction of the use of coal-equivalent product RPF (dry base)
P_{coke} : Fraction of the use of coke-equivalent product RPF (dry base)

- *Emission Factor for MSW Plastics*

It is estimated in the same way as indicated in "8.4.1.1. Municipal Solid Waste Incineration (6.C.1) b) 1) CO_2."

- *Emission Factor for ISW Plastics*

It is estimated in the same way as indicated in " 8.4.1.2. Industrial Waste Incineration (6.C.2) b) 1) CO_2."

Table 8-76 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	808
RPF (coal-equivalent products)	1,419
RPF (coke-equivalent products)	2,445
RPF (weighted average values)	1,627

- ***Activity Data***

➢ ***RDF***

The amount of RDF production is used as the substitute for the amount of use of RDF. Activity data (dry basis) was 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* and also subtracting the amount of biomass-based plastics used as RDF. 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 base)
a_{RDF} : Amount for RDF production at RDF production facilities (wet base) [t]
SC_{RDF} : Fraction of dry matter content of RDF (estimated by (1 – fraction of water content of RDF))

➢ ***Amount of Biomass-based Plastics Contained in RDF (Dry Base)***

It is estimated in the same way as indicated in "8.4.1.1. Municipal Solid Waste Incineration (6.C.1). b) CO_2."

➢ ***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 plastics included in RPF is conisdered to be fossil-fuel derived.

- ***Amount of Biomass-based Plastics Contained in RPF (Wet Base)***

It is estimated in the same way as indicated in "8.4.3.2. Emissions from Industrial Waste (Plastics, Waste Oil, and Wood) Used as Raw Material or Alternative Fuels (1.A.2.) b) 1) CO_2"

Table 8-77 Amount of use of refuse-derived fuel (RDF) or refuse paper & plastic fuel (RPF) (wet basis)

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
RDF	kt (dry)	32	37	140	392	365	355	359	355	355
RPF	kt (dry)	0	8	32	478	751	778	765	807	837

2) ***CH_4, N_2O***

- ***Estimation Method and Emission Factor***

For the estimation method and the emission factors used, see "Emissions from Direct Use of Waste as Fuel (8.4.3)".

Table 8-78 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 was also used for the amount of use of RDF for boiler. The said amount includes the amount of biomass-based plastics.

- ***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 was 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 was 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.

<u>*Activity data converted into energy units*</u>
= (Amount of RDF & RPF consumed [kg (wet)])
×calorific value of corresponding fuel [MJ/kg])/ 10^6

c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of uncertainty in the CO_2 emission factor for RDF used as fuels was estimated by using the uncertainties in the percentage of plastic-derived constituents in RDF, carbon content in the plastics, and combustion rate of the facilities using RDF as fuels. For RPF, the uncertainty in emission factor for coal-equivalent RPF was used. The uncertainty in activity data was estimated by combining the uncertainty for each element because the activity data are estimated by subtracting water content from the amount of RDF and RPF used as fuels (wet basis) to obtain the values on a dry basis.

The uncertainties in the CH_4 and N_2O emission factors are estimated by using the uncertainties in emission factors by usage of RDF and RPF and the calorific values of the RDF and RPF. For activity data, the uncertainties in the amount of RDF and RPF are used.

The methods of evaluation of the uncertainty levels for each component are:

- Use of 95% confidence interval of data: percentage of plastic-derived constituents of RDF, percentage of water content in RDF
- Use of the values for MSW (plastics) incineration: carbon content of RDF and combustion rate for RDF
- Use of the values for ISW (plastics) incineration: carbon content of RPF and combustion rate for RPF
- Expert judgment: percentage of plastic-derived constituents of RPF
- Use of the uncertainties set by each statistics: amount of RDF and RPF used as alternative fuels

The uncertainties in CO_2, CH_4, and N_2O emissions from the use of RDF and RPF as raw materials or alternative fuels are estimated to be 44%, 49%, and 33%, respectively. For details, see the Annex 7.

- ***Time-series Consistency***

Because 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) *Source-specific QA/QC and Verification*

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e) *Source-specific Recalculations*

- Updating the data necessary for estimating biomass-based plastics in the activity data (the amount of plastics disposed of as MSW) for FY 2010 and 2011, emission estimates for the said fiscal years were recalculated.
- Updating the amount of RDF incinerated for FY2011, emission estimates for the said fiscal year were recalculated. For detail, see the section "8.1.3. General Recalculations for Emissions from Waste Sector."

f） ***Source-specific Planned Improvements***

No improvements are planned.

8.5. Other (6.D.)

In this category, CO_2 emissions as a result of the decomposition of petroleum-derived surfactants and CH_4 and N_2O emissions from the composting of organic waste are calculated. Estimated greenhouse gas emissions from category ‘Other’ are shown in Table 8-79. In FY2012, emissions from this source category are 826 Gg-CO_2 eq. and accounted for 0.06% of the national total emissions (excluding LULUCF). The emissions from this source category had decreased by 5.8% compared to those in FY1990. This emission decrease is primarily due to the decrease in CO_2 emissions for FY2001 through FY2004 from the use of alkylbenzenes by introduction of the Pollutant Release and Transfer Register (PRTR).

Table 8-79 GHG emissions from category ‘Other’ (6.D.)

Gas	Category	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO_2	6.D.2. Decomposition of petroleum-derived surfactants	Gg-CO_2	703	668	656	507	530	514	527	524	515
CH_4	6.D.1. Composting of organic waste	Gg-CH_4	4.4	4.2	4.4	7.4	8.3	8.4	7.3	8.0	7.8
		Gg-CO_2 eq	92	89	91	155	175	176	153	169	165
N_2O		Gg-N_2O	0.26	0.25	0.26	0.44	0.50	0.50	0.44	0.48	0.47
		Gg-CO_2 eq	81	79	81	138	155	156	136	150	146
Total of all gases		Gg-CO_2 eq	876	836	828	800	861	846	816	843	826

8.5.1. Emissions from Composting of Organic Waste (6.D.1)

a） ***Source/Sink 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 “Emissions from manure management (4.B)” in the agriculture sector.

b） ***Methodological Issues***

- ***Estimation Method***

Emissions are calculated by taking the amount of organic waste composted, which was obtained from the statistical information available in Japan, and multiplying it by the default emission factor provided in the *IPCC 2006 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 for (dry basis) [kg-CH_4/t], [kg-N_2O/t]

A_{dry} : 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) was obtained by subtracting the water content appropriate to the properties of composted waste from the amount of composted waste (wet basis) listed below:

➢ ***Municipal Solid Waste***

- Amount of composted waste by waste types 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 *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes.*
- Amount of human waste composted at waste composting facilities indicated in the Ministry of the Environment, Waste Management and Recycling Department, *The state of municipal waste treatment survey*.

➢ ***Industrial Solid Waste***

- Amount of sewage sludge treated at composting facilities provided by the *Sewage Statistics*
- Amount of additives(e.g. wood, etc.) to be mixed with sewage sludge treated at composting facilities provided by the *Sewage Statistics.*
- Amount of composted animal and plant residues generated by food and beverage manufacturing is obtained in the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*.
- Amount of composted food waste* other than the above is obtained in the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes.**

*Although under the *Waste Disposal and Pubic Cleansing Act*, they fall under the category of municipal waste, it is included in industrial waste because of its source and properties.

Percentage of water content in composted waste, as indicated in the "Emissions from Controlled Disposal Sites (6.A.1)" section, are; 20% in paper/cardboard, 75% in kitchen waste, 20% in textiles, 45% in wood, and 70% in sewage sludge.

Table 8-80 Amounts of composted waste

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Municipal solid waste	kt (dry)	38	22	29	36	54	69	61	66	60
Industrial solid waste	kt (dry)	400	403	407	704	781	770	669	738	725

c) ***Uncertainties and Time-series Consistency***

- ***Uncertainties***

The uncertainty in emission factor was estimated by using the upper and lower limits for the uncertainty range provided in the *2006 IPCC Guidelines*. For activity data, uncertainty was evaluated on the basis of the statistical uncertainties. The uncertainties in CH_4 and N_2O emissions from composting of organic wastes are estimated to be 74% and 86.3%, respectively. For more details, see the Annex 7.

- ***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 substituted for those year0. 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 the ratio of additives to be added to sewage sludge for FY1996; thus, time series consistency in emission estimates has been ensured.

d） ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with the *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials.

e） ***Source-specific Recalculations***

- Adding the amount of additives (e.g. wood, etc.) in sewage sludge treated at composting facilities into activity data, emission estimates for the period FY1990-2011 were recalculated.
- Reexamining the amount of composted animal and plant residues generated by food manufacturing and food waste other than those, emission estimates for the period FY1990-2011 were recalculated.

f） ***Source-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, and a long-term efforts on scientific investigations will be necessary.

8.5.2. Emissions from the Decomposition of Petroleum-Derived Surfactants (6.D.2)

a） ***Source/Sink 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 (6.A. to 6.C.), it was included in the “Other (6.D.)” 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 *Revised 1996 IPCC Guidelines* nor the *GPG (2000)* specified a method for determining CO_2 emissions, a method specifically established in Japan was 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 was determined for each type of material by calculating the amount of CO_2, expressed in kg that was 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 8-81 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 was no compilation of usage since FY2002, the volume of use was 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 was 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 was 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 8-82 Activity data associated with decomposition of petroleum-based surfactants

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Synthetic alcohol	t	29,239	16,253	28,285	31,609	32,988	32,872	33,750	34,870	35,234
Alkyl benzene	t	105,432	102,794	80,832	47,349	55,442	50,206	50,519	46,369	44,497
Alkyl phenol	t	10,141	8,798	7,454	3,448	2,338	2,044	2,054	2,263	2,238
Ethylene oxide	t	124,984	132,175	146,509	127,150	125,628	126,301	131,148	134,532	132,537

c) ***Uncertainties and Time-series Consistency***

● ***Uncertainty***

The level of uncertainty associated with emission factor was evaluated by using the differences in carbon content in the major constituents of raw materials for surfactants and was found to be 19% (calculated by using standard deviation). With respect to uncertainties in activity data, twice of the statistical uncertainties set out for the statistics (Survey of total population (rounding) and Other statistics) was used and evaluated to be 40%.

● ***Time-series Consistency***

Consistent methodology was 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) ***Source-specific QA/QC and Verification***

Tier 1 QC activities are implemented in accordance with *GPG (2000)*. The Tier 1 QC activities include the verification of parameters such as activity data and emission factors, and the archive of reference materials. For more details of QA/QC activities, see the Annex 6.

e) ***Source-specific Recalculations***

Updating the activity data of surfactants for FY2011, emission estimates for the said fiscal year are recalculated.

f) ***Source-specific Planned Improvements***

No improvements are planned.

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Chapter 9. Other (CRF sector 7)

9.1. Overview of Sector

UNFCCC Reporting Guidelines (FCCC/SBSTA/2006/9) 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 7) are indicated below.

9.2. CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6

Among CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, no emissions and removals are reported in Other sector.

9.3. NOx, CO, NMVOC, and SO_2

Among indirect greenhouse gases (NOx, CO, NMVOC) and SO_2, CO emissions from smoking are reported in Other sector (see Annex 3).

Chapter 10. Recalculation and Improvements

10.1. Explanation and Justification for Recalculations

This section explains improvements on estimation of emissions and removals in the inventory submitted in 2014.

In accordance with the *Good Practice and Uncertainty Management in National Greenhouse Gas Inventories (2000)* and the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry*, recalculations of previously reported emissions and removals are recommended 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

In general, 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 2011 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; solvent and other product use; agriculture; land use, land-use change and forestry; and waste) is described separately at sections named as “Source/Sink-specific Recalculations” in Chapters 3 to 8. Information on recalculations for KP-LULUCF activities are described in section 11.4.1.4 of Chapter 11.

10.2. Implications for Emission Levels

Table 10-1 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 LULUCF sector in the base year (1990) under the UNFCCC increased by 2.41%, and the total emissions in year 2011 decreased by 0.12% compared to the data reported in last year (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 10-7. See each category for details on the reasons of recalculations.

Table 10-1 Comparison of emissions and removals in the inventories submitted in 2013 and 2014

[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
CO_2	JNGI2013	1,071.5	1,073.3	1,082.1	1,072.0	1,130.3	1,143.0	1,151.4	1,146.0	1,110.6	1,145.4	1,165.4	1,150.2	1,186.2	1,182.2	1,182.1	1,193.3	1,179.8	1,213.8	1,135.7	1,067.4	1,115.3	1,165.2
with LULUCF	JNGI2014	1,074.2	1,075.8	1,084.5	1,073.7	1,131.6	1,144.2	1,152.3	1,146.7	1,111.2	1,145.9	1,165.8	1,150.5	1,186.3	1,182.3	1,182.1	1,192.8	1,179.7	1,213.7	1,136.3	1,068.9	1,118.7	1,165.0
	difference	*0.25%*	*0.23%*	*0.22%*	*0.16%*	*0.12%*	*0.10%*	*0.08%*	*0.06%*	*0.06%*	*0.04%*	*0.03%*	*0.02%*	*0.01%*	*0.01%*	*0.00%*	*-0.04%*	*-0.01%*	*-0.01%*	*0.06%*	*0.15%*	*0.31%*	*-0.02%*
CO_2	JNGI2013	1,141.1	1,150.1	1,158.5	1,150.9	1,210.7	1,223.7	1,236.6	1,231.5	1,195.9	1,230.8	1,251.5	1,236.3	1,273.4	1,278.5	1,277.9	1,282.1	1,262.9	1,296.2	1,213.8	1,141.5	1,191.1	1,240.7
without LULUCF	JNGI2014	1,141.1	1,150.1	1,158.5	1,150.9	1,210.7	1,223.7	1,236.6	1,231.5	1,195.9	1,230.8	1,251.5	1,236.3	1,273.4	1,278.5	1,277.9	1,282.1	1,263.0	1,296.2	1,213.8	1,141.5	1,191.1	1,240.6
	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%*
CH_4	JNGI2013	32.1	31.9	31.6	31.4	30.7	29.9	29.2	28.1	27.3	26.7	26.1	25.2	24.3	23.8	23.4	23.0	22.7	22.3	21.8	21.2	20.7	20.3
with LULUCF	JNGI2014	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6	26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1	20.7	20.3
	difference	*0.88%*	*0.48%*	*0.16%*	*-0.87%*	*-0.88%*	*-0.69%*	*-1.14%*	*-0.42%*	*-0.44%*	*-0.56%*	*-0.52%*	*-0.47%*	*-0.41%*	*-0.40%*	*-0.41%*	*-0.42%*	*-0.39%*	*-0.54%*	*-0.35%*	*-0.35%*	*-0.22%*	*-0.06%*
CH_4	JNGI2013	32.1	31.9	31.6	31.4	30.7	29.9	29.1	28.1	27.3	26.7	26.1	25.2	24.3	23.8	23.4	23.0	22.7	22.3	21.8	21.2	20.7	20.3
without LULUCF	JNGI2014	32.4	32.0	31.7	31.1	30.5	29.7	28.8	28.0	27.2	26.6	26.0	25.1	24.2	23.7	23.3	22.9	22.6	22.2	21.7	21.1	20.7	20.3
	difference	*0.88%*	*0.48%*	*0.16%*	*-0.87%*	*-0.88%*	*-0.69%*	*-1.14%*	*-0.42%*	*-0.44%*	*-0.56%*	*-0.52%*	*-0.47%*	*-0.41%*	*-0.40%*	*-0.41%*	*-0.43%*	*-0.39%*	*-0.54%*	*-0.35%*	*-0.35%*	*-0.22%*	*-0.06%*
N_2O	JNGI2013	32.1	31.6	31.8	31.5	32.7	33.2	34.2	34.8	33.3	26.9	29.4	26.0	25.3	24.9	24.9	24.4	24.4	23.2	23.1	23.0	22.4	22.0
with LULUCF	JNGI2014	29.8	29.3	29.5	29.4	30.6	31.1	32.1	32.8	31.3	24.9	27.5	24.2	23.6	23.3	23.4	23.0	23.0	21.9	21.7	21.5	20.8	20.5
	difference	*-7.19%*	*-7.19%*	*-7.05%*	*-6.87%*	*-6.47%*	*-6.42%*	*-6.02%*	*-5.82%*	*-6.05%*	*-7.36%*	*-6.46%*	*-6.92%*	*-6.69%*	*-6.43%*	*-6.11%*	*-5.92%*	*-5.64%*	*-5.76%*	*-6.03%*	*-6.53%*	*-7.10%*	*-6.76%*
N_2O	JNGI2013	32.0	31.5	31.7	31.5	32.7	33.1	34.1	34.8	33.3	26.8	29.4	26.0	25.2	24.9	24.9	24.4	24.4	23.2	23.1	22.9	22.4	22.0
without LULUCF	JNGI2014	29.7	29.3	29.5	29.3	30.6	31.0	32.1	32.8	31.3	24.9	27.5	24.2	23.5	23.3	23.4	23.0	23.0	21.8	21.7	21.4	20.8	20.5
	difference	*-7.21%*	*-7.21%*	*-7.06%*	*-6.89%*	*-6.49%*	*-6.43%*	*-6.03%*	*-5.83%*	*-6.06%*	*-7.37%*	*-6.47%*	*-6.93%*	*-6.70%*	*-6.43%*	*-6.12%*	*-5.93%*	*-5.65%*	*-5.77%*	*-6.03%*	*-6.54%*	*-7.10%*	*-6.76%*
HFCs	JNGI2013	NE	NE	NE	NE	NE	20.3	19.9	19.9	19.4	19.9	18.8	16.2	13.7	13.8	10.6	10.5	11.7	13.3	15.3	16.6	18.3	20.5
	JNGI2014	12.6	13.7	14.1	14.4	16.8	20.3	19.9	19.9	19.4	19.9	18.8	16.2	13.7	13.8	10.6	10.5	11.7	13.3	15.3	16.5	18.3	20.5
	difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*-0.09%*	*-0.08%*
PFCs	JNGI2013	NE	NE	NE	NE	NE	14.3	14.8	16.2	13.4	10.4	9.6	8.0	7.4	7.2	7.5	7.0	7.3	6.4	4.6	3.3	3.4	3.0
	JNGI2014	5.3	6.1	6.2	8.9	10.9	14.3	14.8	16.2	13.4	10.4	9.6	8.0	7.4	7.2	7.5	7.0	7.3	6.4	4.6	3.3	3.4	3.0
	difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
SF_6	JNGI2013	NE	NE	NE	NE	NE	17.0	17.5	15.0	13.6	9.3	7.2	6.0	5.6	5.3	5.1	4.8	4.9	4.4	3.8	1.9	1.9	1.6
	JNGI2014	13.2	14.7	16.2	16.2	15.4	17.0	17.5	15.0	13.6	9.3	7.2	6.0	5.6	5.3	5.1	4.8	4.9	4.4	3.8	1.9	1.9	1.6
	difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*-0.90%*	*0.00%*	*0.00%*	*0.00%*
Total	JNGI2013	1,135.8	1,136.8	1,145.5	1,134.9	1,193.8	1,257.6	1,266.9	1,260.0	1,217.7	1,238.6	1,256.6	1,231.5	1,262.4	1,257.1	1,253.5	1,263.0	1,250.9	1,283.4	1,204.3	1,133.2	1,182.0	1,232.7
with LULUCF	JNGI2014	1,167.5	1,171.6	1,182.1	1,173.7	1,235.9	1,256.5	1,265.5	1,258.6	1,216.1	1,237.0	1,254.9	1,229.8	1,260.8	1,255.5	1,251.9	1,261.0	1,249.2	1,281.8	1,203.4	1,133.2	1,183.7	1,230.9
	difference	*2.79%*	*3.07%*	*3.20%*	*3.41%*	*3.53%*	*-0.09%*	*-0.12%*	*-0.11%*	*-0.12%*	*-0.13%*	*-0.14%*	*-0.14%*	*-0.13%*	*-0.13%*	*-0.13%*	*-0.16%*	*-0.13%*	*-0.12%*	*-0.07%*	*0.00%*	*0.15%*	*-0.14%*
Total	JNGI2013	1,205.3	1,213.5	1,221.9	1,213.7	1,274.1	1,338.2	1,352.1	1,345.5	1,302.9	1,324.0	1,342.6	1,317.6	1,349.6	1,353.4	1,349.3	1,351.9	1,334.0	1,365.7	1,282.4	1,207.3	1,257.7	1,308.1
without LULUCF	JNGI2014	1,234.3	1,245.8	1,256.1	1,250.8	1,314.8	1,335.9	1,349.7	1,343.3	1,300.7	1,321.9	1,340.5	1,315.7	1,347.8	1,351.7	1,347.6	1,350.3	1,332.5	1,364.3	1,280.9	1,205.7	1,256.1	1,306.5
	difference	*2.41%*	*2.66%*	*2.80%*	*3.05%*	*3.20%*	*-0.17%*	*-0.18%*	*-0.16%*	*-0.16%*	*-0.16%*	*-0.15%*	*-0.15%*	*-0.13%*	*-0.13%*	*-0.12%*	*-0.11%*	*-0.11%*	*-0.11%*	*-0.12%*	*-0.13%*	*-0.13%*	*-0.12%*

Table 10-2 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Energy sector)

1. Energy [Gg-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
A. Fuel Combustion	CO_2	JNGI2013	324,253.2	326,986.6	333,717.4	315,598.9	356,359.5	344,948.2	345,134.7	342,054.2	332,405.3	349,785.3	357,574.1	349,730.2	381,372.6	395,368.4	390,980.5	406,038.5	394,358.5	447,301.9	420,886.9	385,493.2	405,372.4	466,617.2
1. Energy Industries		JNGI2014	324,253.2	326,986.6	333,717.4	315,598.9	356,359.5	344,948.2	345,134.7	342,054.2	332,405.3	349,785.3	357,574.1	349,730.2	381,372.6	395,368.4	390,980.5	406,038.5	394,358.5	447,301.9	420,888.4	385,493.1	405,371.7	466,935.3
		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%*	*0.07%*
	CH_4	JNGI2013	29.7	31.2	31.9	31.6	33.8	34.4	36.2	38.0	39.8	42.7	42.6	41.6	32.4	32.0	30.1	31.4	31.4	34.1	31.4	29.7	32.5	36.9
		JNGI2014	29.7	31.2	31.9	31.7	33.8	34.4	36.2	38.1	39.8	42.7	42.6	41.6	32.4	32.0	30.1	31.4	31.4	34.1	31.4	29.7	41.9	68.7
		difference	*0.02%*	*0.03%*	*0.06%*	*0.05%*	*0.04%*	*0.04%*	*0.06%*	*0.05%*	*0.04%*	*0.04%*	*0.04%*	*0.03%*	*0.01%*	*0.05%*	*0.00%*	*0.07%*	*0.15%*	*0.07%*	*0.00%*	*0.00%*	*28.73%*	*85.99%*
	N_2O	JNGI2013	922.3	955.5	929.8	938.3	1,010.4	1,413.3	1,444.4	1,490.1	1,515.2	1,615.9	1,700.0	1,912.3	1,837.0	1,863.1	1,855.3	2,067.7	2,046.3	2,096.4	2,022.3	1,934.3	1,903.0	1,990.2
		JNGI2014	922.3	955.5	929.8	938.4	1,010.4	1,413.3	1,444.4	1,490.1	1,515.2	1,615.9	1,700.0	1,912.3	1,837.0	1,863.1	1,855.3	2,067.7	2,046.3	2,096.4	2,022.3	1,934.3	1,915.6	2,063.6
		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%*	*0.66%*	*3.69%*
A. Fuel Combustion	CO_2	JNGI2013	371,311.5	366,282.9	358,404.8	357,499.5	365,878.2	370,539.4	378,811.7	381,142.9	357,839.0	365,074.8	376,777.8	366,481.4	372,969.3	373,173.4	378,734.3	371,229.4	373,289.0	370,257.4	335,621.0	319,043.1	342,744.2	335,186.4
2. Manufacturing Industries		JNGI2014	371,311.5	366,282.9	358,404.8	357,499.5	365,878.2	370,539.4	378,811.7	381,142.9	357,839.0	365,074.8	376,777.8	366,481.4	372,969.3	373,173.4	378,734.3	371,229.4	373,314.5	370,259.3	335,621.0	319,093.4	342,657.4	334,882.5
and Construction		*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%*	*0.01%*	*0.00%*	*0.00%*	*0.02%*	*-0.03%*	*-0.09%*
	CH_4	JNGI2013	355.5	356.1	352.2	353.0	361.9	437.6	380.7	362.0	324.3	328.5	354.9	333.6	343.4	368.2	382.6	386.9	412.0	438.5	437.8	436.4	472.8	462.9
		JNGI2014	355.4	355.9	351.6	353.0	362.0	364.2	380.8	362.7	325.3	327.9	354.5	333.4	343.3	368.3	382.8	387.0	412.2	438.7	437.8	436.4	516.5	511.8
		difference	*-0.04%*	*-0.08%*	*-0.16%*	*0.01%*	*0.01%*	*-16.77%*	*0.00%*	*0.20%*	*0.32%*	*-0.17%*	*-0.11%*	*-0.06%*	*-0.03%*	*0.01%*	*0.03%*	*0.04%*	*0.05%*	*0.03%*	*0.01%*	*0.01%*	*9.23%*	*10.58%*
	N_2O	JNGI2013	1,350.1	1,426.6	1,541.6	1,579.7	1,718.1	1,871.0	1,931.7	2,060.4	1,985.4	2,073.5	2,116.5	2,068.0	2,081.8	2,049.8	2,070.8	2,036.1	2,009.1	2,062.8	1,988.2	1,916.9	1,901.9	1,884.2
		JNGI2014	1,354.1	1,430.1	1,544.9	1,602.8	1,743.3	1,828.7	1,934.4	2,063.2	1,988.7	2,073.7	2,116.4	2,070.4	2,083.1	2,050.5	2,070.7	2,036.1	2,009.3	2,063.0	1,988.5	1,917.3	1,987.9	1,966.6
		difference	*0.29%*	*0.25%*	*0.21%*	*1.47%*	*1.46%*	*-2.27%*	*0.14%*	*0.14%*	*0.17%*	*0.01%*	*0.00%*	*0.11%*	*0.06%*	*0.03%*	*0.00%*	*0.00%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*4.52%*	*4.38%*
A. Fuel Combustion	CO_2	JNGI2013	211,053.7	222,466.8	226,859.7	231,727.9	243,681.0	251,166.5	256,750.6	258,734.1	257,853.9	260,017.2	259,076.4	261,120.7	255,478.9	252,947.2	252,413.9	247,009.7	243,632.5	237,831.0	228,099.2	222,768.4	225,459.8	222,132.6
3. Transport		JNGI2014	211,056.8	222,469.9	226,863.5	231,732.6	243,687.0	251,176.6	256,765.2	258,754.3	257,884.7	260,061.0	259,138.2	261,213.8	255,606.6	253,106.6	252,586.7	247,211.9	243,855.4	238,065.4	228,349.1	223,043.0	225,507.6	221,559.1
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.01%*	*0.01%*	*0.02%*	*0.02%*	*0.04%*	*0.05%*	*0.06%*	*0.07%*	*0.08%*	*0.09%*	*0.10%*	*0.11%*	*0.12%*	*0.02%*	*-0.26%*
	CH_4	JNGI2013	297.5	300.0	303.0	295.9	297.6	308.8	314.6	315.7	304.7	303.5	298.4	292.8	282.2	270.3	250.5	237.8	222.2	208.0	191.8	179.9	169.8	161.6
		JNGI2014	294.7	297.2	300.3	293.2	295.0	306.3	312.3	313.5	302.6	301.6	296.6	291.0	280.3	268.0	247.8	234.9	218.9	204.3	188.0	175.9	165.9	157.7
		difference	*-0.96%*	*-0.92%*	*-0.89%*	*-0.90%*	*-0.86%*	*-0.80%*	*-0.74%*	*-0.71%*	*-0.70%*	*-0.63%*	*-0.61%*	*-0.62%*	*-0.69%*	*-0.85%*	*-1.07%*	*-1.22%*	*-1.49%*	*-1.77%*	*-1.98%*	*-2.22%*	*-2.25%*	*-2.42%*
	N_2O	JNGI2013	4,205.7	4,368.8	4,460.9	4,433.9	4,515.1	4,651.7	4,738.7	4,786.9	4,688.4	4,681.9	4,589.3	4,412.3	4,150.9	3,879.8	3,572.8	3,321.0	3,142.9	3,008.1	2,851.1	2,681.8	2,533.5	2,411.5
		JNGI2014	4,217.9	4,379.1	4,468.3	4,439.9	4,519.4	4,655.1	4,740.9	4,786.3	4,681.9	4,668.0	4,570.0	4,390.0	4,126.5	3,853.8	3,545.9	3,294.1	3,114.7	2,979.0	2,822.3	2,652.8	2,492.0	2,367.1
		difference	*0.29%*	*0.23%*	*0.17%*	*0.14%*	*0.10%*	*0.07%*	*0.05%*	*-0.01%*	*-0.14%*	*-0.30%*	*-0.42%*	*-0.50%*	*-0.59%*	*-0.67%*	*-0.76%*	*-0.81%*	*-0.90%*	*-0.97%*	*-1.01%*	*-1.08%*	*-1.64%*	*-1.84%*
A. Fuel Combustion	CO_2	JNGI2013	161,641.2	160,314.9	164,488.0	172,284.7	167,240.4	179,115.0	177,212.5	172,969.5	176,892.1	185,232.0	186,615.4	190,052.7	198,067.6	192,399.5	191,858.1	193,419.3	187,999.0	177,974.6	168,436.2	161,500.0	163,405.5	162,668.3
4. Other Sectors		JNGI2014	161,638.1	160,311.8	164,484.2	172,280.1	167,234.4	179,105.0	177,197.9	172,949.2	176,861.3	185,188.2	186,553.6	189,959.6	197,939.9	192,240.1	191,685.3	193,217.1	187,776.1	177,740.2	168,186.2	161,172.8	163,444.7	163,560.4
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.02%*	*-0.02%*	*-0.03%*	*-0.05%*	*-0.06%*	*-0.08%*	*-0.09%*	*-0.10%*	*-0.12%*	*-0.13%*	*-0.15%*	*-0.20%*	*0.02%*	*0.55%*
	CH_4	JNGI2013	207.4	209.1	224.1	249.6	235.4	257.1	230.3	235.4	252.5	275.8	263.4	259.5	258.8	223.7	232.0	258.0	253.3	240.7	229.9	219.1	232.9	197.6
		JNGI2014	207.4	209.1	227.9	249.5	235.0	258.6	230.7	235.5	252.5	275.7	263.3	259.3	258.6	223.5	231.8	257.8	253.0	240.5	229.7	218.8	232.9	197.8
		difference	*0.00%*	*0.00%*	*1.71%*	*-0.05%*	*-0.14%*	*0.59%*	*0.19%*	*0.06%*	*-0.01%*	*-0.03%*	*-0.04%*	*-0.06%*	*-0.08%*	*-0.11%*	*-0.10%*	*-0.10%*	*-0.11%*	*-0.11%*	*-0.11%*	*-0.13%*	*0.00%*	*0.10%*
	N_2O	JNGI2013	273.5	279.9	294.5	323.6	326.9	348.3	302.6	305.6	323.8	358.7	356.0	355.1	363.5	343.8	345.9	351.9	346.8	335.9	322.5	312.6	325.2	323.5
		JNGI2014	273.5	279.9	295.9	323.3	325.8	352.0	302.6	305.7	323.7	358.6	355.9	354.9	363.1	343.4	345.5	351.4	346.2	335.2	321.8	311.8	325.3	328.5
		difference	*0.00%*	*0.00%*	*0.50%*	*-0.12%*	*-0.34%*	*1.05%*	*0.00%*	*0.03%*	*-0.03%*	*-0.05%*	*-0.05%*	*-0.07%*	*-0.09%*	*-0.12%*	*-0.13%*	*-0.15%*	*-0.17%*	*-0.19%*	*-0.21%*	*-0.26%*	*0.04%*	*1.55%*
B. Fugitive Emissions	CH_4	JNGI2013	2,806.4	2,538.3	2,267.5	2,075.8	1,713.0	1,344.7	1,297.2	1,006.9	872.5	865.7	769.1	570.3	118.3	93.9	66.5	73.6	68.1	51.5	45.8	46.2	44.5	44.7
1. Solid Fuels		JNGI2014	3,235.5	2,830.3	2,453.3	1,937.3	1,584.9	1,344.0	1,088.4	1,006.9	873.1	837.8	749.2	570.3	118.3	93.9	66.5	64.9	68.1	51.5	45.8	46.2	44.5	44.7
		difference	*15.29%*	*11.50%*	*8.19%*	*-6.67%*	*-7.48%*	*-0.05%*	*-16.09%*	*0.00%*	*0.07%*	*-3.22%*	*-2.59%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-11.76%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
B. Fugitive Emissions	CO_2	JNGI2013	36.6	53.7	57.0	53.2	51.1	50.9	49.4	48.0	42.7	38.1	36.0	32.4	30.9	34.5	35.0	37.6	35.9	37.5	37.8	35.1	33.1	32.5
2. Oil and Natural Gas		JNGI2014	36.6	53.7	57.0	53.2	51.1	50.9	49.4	48.0	42.7	38.1	36.0	32.4	30.9	34.5	35.0	37.6	35.9	37.5	37.8	35.1	33.1	32.5
		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%*
	CH_4	JNGI2013	230.7	256.4	259.8	263.5	266.6	265.2	263.3	270.4	265.5	262.7	274.0	267.9	288.1	295.5	306.5	322.2	340.1	364.7	362.5	348.0	331.3	329.7
		JNGI2014	230.7	256.4	259.8	263.5	266.6	265.2	263.3	270.4	265.5	262.7	274.0	267.9	288.1	295.5	306.5	322.2	340.1	364.7	362.5	348.0	331.3	329.8
		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%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
	N_2O	JNGI2013	0.1	0.2	0.2	0.2	0.2	0.2	0.2	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
		JNGI2014	0.1	0.2	0.2	0.2	0.2	0.2	0.2	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%*
1. Total	GHG	JNGI2013	1,078,975	1,086,827	1,094,192	1,087,709	1,143,689	1,156,752	1,168,899	1,165,820	1,135,605	1,170,956	1,190,844	1,177,931	1,217,676	1,223,343	1,223,135	1,226,821	1,208,187	1,242,243	1,161,565	1,096,945	1,144,962	1,194,480
		JNGI2014	1,079,418	1,087,130	1,094,391	1,087,597	1,143,587	1,156,642	1,168,693	1,165,821	1,135,601	1,170,912	1,190,802	1,177,909	1,217,650	1,223,315	1,223,105	1,226,782	1,208,181	1,242,212	1,161,533	1,096,909	1,145,068	1,195,006
		difference	*0.04%*	*0.03%*	*0.02%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.02%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.04%*

Table 10-3 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Industrial Processes sector)

2. Industrial Processes [Gg-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
A. Mineral Products	CO_2	JNGI2013	55,310.5	56,474.6	56,567.1	55,713.2	56,690.4	56,756.1	57,088.7	54,453.0	49,384.1	49,100.5	49,745.6	48,847.8	46,234.6	45,640.1	45,407.9	46,773.9	46,878.9	46,010.3	42,883.3	37,589.2	38,177.2	38,343.7
		JNGI2014	55,310.5	56,474.6	56,567.1	55,713.2	56,690.4	56,756.1	57,088.7	54,453.0	49,384.1	49,100.5	49,745.6	48,847.8	46,234.6	45,640.1	45,407.9	46,773.9	46,878.9	46,010.3	42,883.3	37,589.2	38,176.9	38,391.4
		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%*	*0.12%*
B. Chemical Industry	CO_2	JNGI2013	4,209.1	4,184.4	4,101.1	3,894.8	4,145.1	4,219.6	4,203.4	4,144.2	3,639.8	3,965.1	3,893.0	3,598.6	3,385.5	3,128.6	3,171.8	2,886.9	2,918.7	2,990.4	2,574.1	2,488.2	2,737.2	2,629.2
		JNGI2014	4,209.1	4,184.4	4,101.1	3,894.8	4,145.1	4,219.6	4,203.4	4,144.2	3,639.8	3,965.1	3,893.0	3,598.6	3,385.5	3,128.6	3,171.8	2,886.9	2,918.7	2,990.4	2,574.1	2,488.2	2,737.2	2,629.2
		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%*
	CH_4	JNGI2013	338.2	329.2	304.5	303.9	303.4	304.4	293.8	242.6	227.4	220.1	179.0	131.7	124.9	117.4	126.6	117.0	116.0	116.9	106.5	96.7	104.1	105.1
		JNGI2014	338.1	328.7	303.7	303.1	302.5	303.5	293.0	241.9	226.8	219.7	178.5	131.2	124.4	116.9	126.1	116.5	115.5	116.4	105.9	96.1	103.4	104.5
		difference	*-0.05%*	*-0.13%*	*-0.24%*	*-0.25%*	*-0.28%*	*-0.31%*	*-0.28%*	*-0.28%*	*-0.27%*	*-0.21%*	*-0.25%*	*-0.35%*	*-0.39%*	*-0.43%*	*-0.38%*	*-0.44%*	*-0.46%*	*-0.48%*	*-0.58%*	*-0.61%*	*-0.60%*	*-0.58%*
	N_2O	JNGI2013	8,266.9	7,539.7	7,452.4	7,302.8	8,298.1	8,212.7	9,220.1	9,792.5	8,577.9	2,000.9	4,690.1	1,414.9	1,238.8	1,259.5	1,657.6	1,299.9	1,624.7	860.2	1,262.2	1,559.5	1,077.7	787.6
		JNGI2014	8,266.9	7,539.7	7,452.4	7,302.8	8,298.1	8,212.7	9,220.1	9,792.5	8,577.9	2,000.9	4,690.1	1,414.9	1,238.8	1,259.5	1,657.6	1,299.9	1,624.7	860.2	1,262.2	1,559.5	1,077.7	787.6
		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%*
C. Metal Production	CO_2	JNGI2013	356.1	323.0	325.0	330.8	345.8	357.2	380.0	384.5	293.1	254.5	248.4	210.7	220.9	241.6	257.8	241.9	177.6	212.0	155.8	112.0	159.9	161.7
		JNGI2014	356.1	323.0	325.0	330.8	345.8	357.2	380.0	384.5	293.1	254.5	248.4	210.7	220.9	241.6	257.8	241.9	177.6	212.0	155.8	112.0	159.9	161.7
		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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	CH_4	JNGI2013	19.4	18.3	17.8	16.7	17.5	17.9	18.2	18.3	16.1	16.1	16.8	15.8	16.6	16.5	17.0	16.9	17.2	17.3	15.0	13.0	14.9	15.2
		JNGI2014	19.4	18.3	17.8	16.7	17.5	17.9	18.2	18.3	16.1	16.1	16.8	15.8	16.6	16.5	17.0	16.9	17.2	17.3	15.0	13.0	14.9	15.1
		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%*	*-0.63%*
	HFCs	JNGI2013	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
		JNGI2014	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0.9
		difference	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
	PFCs	JNGI2013	NE	NE	NE	NE	NE	69.7	65.9	59.4	49.4	29.1	17.8	15.7	14.8	15.2	14.8	14.8	14.8	14.7	14.7	11.0	10.4	10.4
		JNGI2014	137.2	115.1	77.2	71.1	70.9	69.7	65.9	59.4	49.4	29.1	17.8	15.7	14.8	15.2	14.8	14.8	14.8	14.7	14.7	11.0	10.4	10.4
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2013	NE	NE	NE	NE	NE	119.5	143.4	191.2	406.3	645.3	1027.7	1147.2	1123.3	1125.5	1111.0	1157.3	1091.1	1089.3	652.5	239.0	307.9	191.2
		JNGI2014	153.6	132.5	112.2	117.8	114.4	119.5	143.4	191.2	406.3	645.3	1027.7	1147.2	1123.3	1125.5	1111.0	1157.3	1091.1	1089.3	652.5	239.0	307.9	191.2
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
E. Production of	HFCs	JNGI2013	NE	NE	NE	NE	NE	17,445.1	16,052.3	15,078.0	14,053.4	14,260.6	12,659.8	9,713.4	6,456.6	5,459.5	1,469.7	816.0	938.2	497.6	701.4	222.1	128.3	112.5
Halocarbons and SF_6		JNGI2014	12,593.6	13,715.6	13,936.7	13,528.4	14,994.0	17,445.1	16,052.3	15,078.0	14,053.4	14,260.6	12,659.8	9,713.4	6,456.6	5,459.5	1,469.7	816.0	938.2	497.6	702.0	222.1	128.3	112.5
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.08%*	*0.00%*	*0.00%*	*0.03%*
	PFCs	JNGI2013	NE	NE	NE	NE	NE	762.9	1,007.8	1,416.8	1,389.5	1,270.9	1,359.0	1,082.6	1,009.9	965.6	866.8	837.5	879.1	783.0	523.8	399.5	200.2	171.9
		JNGI2014	276.1	319.7	326.9	472.2	581.2	762.9	1,007.8	1,416.8	1,389.5	1,270.9	1,359.0	1,082.6	1,009.9	965.6	866.8	837.5	879.1	783.0	523.8	399.5	200.2	171.9
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2013	NE	NE	NE	NE	NE	4,708.3	4,182.5	2,581.2	2,103.2	1,529.6	860.4	788.7	860.4	812.6	764.8	975.1	1,366.4	1,198.8	1,288.2	260.5	198.4	138.6
		JNGI2014	3,638.2	4,066.3	4,494.3	4,494.3	4,280.3	4,708.3	4,182.5	2,581.2	2,103.2	1,529.6	860.4	788.7	860.4	812.6	764.8	975.1	1,366.4	1,198.8	1,288.2	260.5	198.4	138.6
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
F. Consumption of	HFCs	JNGI2013	NE	NE	NE	NE	NE	2,815.0	3,853.9	4,827.1	5,362.5	5,673.9	6,140.6	6,454.6	7,236.4	8,302.2	9,082.7	9,702.2	10,804.0	12,781.6	14,596.9	16,332.0	18,178.9	20,354.5
Halocarbons and SF_6		JNGI2014	1.6	18,070.0	121.8	900.5	1,855.3	2,815.0	3,853.9	4,827.1	5,362.5	5,673.9	6,140.6	6,454.6	7,236.4	8,302.2	9,082.7	9,702.2	10,804.0	12,781.6	14,596.9	16,324.5	18,163.0	20,338.1
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*-0.09%*	*-0.08%*
	PFCs	JNGI2012	NE	NE	NE	NE	NE	13,438.6	13,698.4	14,711.4	11,962.8	9,128.8	8,206.6	6,855.2	6,408.8	6,197.9	6,596.8	6,138.4	6,417.3	5,602.9	4,076.6	2,854.8	3,198.1	2,834.1
		JNGI2013	4,863.5	5,631.4	5,759.4	8,319.1	10,238.9	13,438.6	13,698.4	14,711.4	11,962.8	9,128.8	8,206.6	6,855.2	6,408.8	6,197.9	6,596.8	6,138.4	6,417.3	5,602.9	4,076.6	2,854.8	3,198.1	2,834.1
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
	SF_6	JNGI2013	NE	NE	NE	NE	NE	12,133.7	13,209.4	12,225.7	11,114.6	7,135.0	5,300.4	4,026.5	3,595.8	3,315.8	3,220.1	2,675.5	2,453.4	2,119.3	1,854.5	1,351.8	1,356.2	1,308.0
		JNGI2014	9,376.0	10,479.1	11,582.1	11,582.1	11,030.6	12,133.7	13,209.4	12,225.7	11,114.6	7,135.0	5,300.4	4,026.5	3,595.8	3,315.8	3,220.1	2,675.5	2,453.4	2,119.3	1,820.5	1,351.8	1,356.2	1,308.0
		difference	*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%*	*0.00%*	*0.00%*	*0.00%*	*-1.83%*	*0.00%*	*0.00%*	*0.00%*
2. Total	GHG	JNGI2013	68,500.2	68,869.3	68,767.8	67,562.2	69,800.2	121,360.8	123,417.8	120,125.9	108,580.3	95,230.4	94,345.2	84,303.5	77,927.5	76,598.1	73,765.6	73,653.4	75,697.4	74,294.5	70,705.4	63,529.2	65,849.4	67,163.8
		JNGI2014	99,539.9	121,398.4	105,177.6	107,046.9	112,964.9	121,359.8	123,417.0	120,125.2	108,579.6	95,229.9	94,344.7	84,303.1	77,927.0	76,597.6	73,765.1	73,652.9	75,696.9	74,293.9	70,671.4	63,521.1	65,832.6	67,195.2
		difference	*45.31%*	*76.27%*	*52.95%*	*58.44%*	*61.84%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.05%*	*-0.01%*	*-0.03%*	*0.05%*

Table 10-4 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Solvent and other product use sector)

3. Solvent and Other Product Use [Gg-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
D. Other	N_2O	JNGI2013	287.1	356.8	413.0	411.7	438.0	437.6	420.9	404.6	377.1	362.5	341.0	343.6	334.1	320.8	297.5	266.4	242.3	160.0	129.1	120.5	99.0	97.1
		JNGI2014	287.1	356.8	413.0	411.7	438.0	437.6	420.9	404.6	377.1	362.5	341.0	343.6	334.1	320.8	297.5	266.4	242.3	160.0	129.1	120.5	99.0	97.1
		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%*
3. Total	GHG	JNGI2013	287.1	356.8	413.0	411.7	438.0	437.6	420.9	404.6	377.1	362.5	341.0	343.6	334.1	320.8	297.5	266.4	242.3	160.0	129.1	120.5	99.0	97.1
		JNGI2014	287.1	356.8	413.0	411.7	438.0	437.6	420.9	404.6	377.1	362.5	341.0	343.6	334.1	320.8	297.5	266.4	242.3	160.0	129.1	120.5	99.0	97.1
		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%*

Table 10-5 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Agriculture sector)

4. Agriculture [Gg-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
A. Enteric	CH_4	JNGI2013	7,676.6	7,787.9	7,830.2	7,781.4	7,691.9	7,606.4	7,551.5	7,505.5	7,466.8	7,407.8	7,370.0	7,325.2	7,276.1	7,163.2	7,063.7	7,001.9	6,999.9	6,974.2	6,912.8	6,773.0	6,657.6	6,567.8
Fermentation		JNGI2014	7,549.8	7,661.7	7,705.9	7,659.6	7,572.6	7,489.3	7,436.4	7,392.9	7,356.8	7,300.7	7,265.4	7,222.7	7,175.9	7,066.3	6,970.6	6,911.9	6,912.2	6,888.5	6,829.3	6,691.4	6,577.0	6,440.8
		difference	*-1.65%*	*-1.62%*	*-1.59%*	*-1.57%*	*-1.55%*	*-1.54%*	*-1.52%*	*-1.50%*	*-1.47%*	*-1.44%*	*-1.42%*	*-1.40%*	*-1.38%*	*-1.35%*	*-1.32%*	*-1.29%*	*-1.25%*	*-1.23%*	*-1.21%*	*-1.20%*	*-1.21%*	*-1.93%*
B. Manure	CH_4	JNGI2013	2,944.2	2,937.4	2,910.0	2,853.2	2,795.4	2,747.5	2,714.4	2,673.6	2,629.4	2,578.5	2,540.5	2,515.9	2,496.9	2,460.5	2,418.6	2,373.2	2,334.0	2,290.7	2,238.0	2,184.5	2,143.8	2,127.5
Management		JNGI2014	2,948.7	2,941.6	2,914.1	2,857.5	2,799.8	2,751.8	2,718.8	2,678.5	2,634.6	2,581.1	2,538.3	2,507.2	2,482.6	2,441.4	2,395.9	2,347.1	2,305.6	2,260.1	2,222.6	2,185.1	2,161.5	2,134.3
		difference	*0.15%*	*0.14%*	*0.14%*	*0.15%*	*0.16%*	*0.16%*	*0.16%*	*0.18%*	*0.20%*	*0.10%*	*-0.08%*	*-0.35%*	*-0.57%*	*-0.78%*	*-0.94%*	*-1.10%*	*-1.22%*	*-1.34%*	*-0.69%*	*0.03%*	*0.83%*	*0.32%*
	N_2O	JNGI2013	5,501.5	5,469.5	5,425.3	5,332.0	5,219.4	5,121.3	5,059.5	5,002.7	4,958.9	4,906.0	4,857.4	4,811.9	4,784.9	4,753.8	4,729.2	4,728.6	4,748.1	4,771.8	5,006.5	5,215.1	5,412.5	5,372.3
		JNGI2014	3,171.4	3,172.7	3,163.0	3,125.5	3,072.6	3,020.8	2,986.6	2,961.4	2,939.7	2,943.4	2,983.0	3,064.1	3,152.2	3,231.2	3,309.2	3,401.5	3,513.7	3,631.2	3,733.6	3,775.8	3,778.8	3,734.2
		difference	*-42.35%*	*-41.99%*	*-41.70%*	*-41.38%*	*-41.13%*	*-41.02%*	*-40.97%*	*-40.80%*	*-40.72%*	*-40.00%*	*-38.59%*	*-36.32%*	*-34.12%*	*-32.03%*	*-30.03%*	*-28.06%*	*-26.00%*	*-23.90%*	*-25.42%*	*-27.60%*	*-30.18%*	*-30.49%*
C. Rice Cultivation	CH_4	JNGI2013	6,959.7	6,977.7	7,059.0	7,247.6	7,263.4	7,082.7	6,793.7	6,440.3	6,229.1	6,024.8	5,919.8	5,810.2	5,693.9	5,690.6	5,712.0	5,739.1	5,707.5	5,652.2	5,598.6	5,544.8	5,477.1	5,433.7
		JNGI2014	6,959.7	6,977.7	7,059.0	7,247.6	7,263.4	7,082.7	6,793.7	6,440.3	6,229.1	6,024.8	5,919.8	5,810.2	5,693.9	5,690.6	5,712.0	5,739.1	5,707.5	5,652.2	5,598.6	5,544.8	5,477.1	5,459.8
		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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.48%*
D. Agricultural Soils	N_2O	JNGI2013	8,355.7	8,214.2	8,142.0	8,070.6	7,902.7	7,682.4	7,477.0	7,339.9	7,239.5	7,191.3	7,151.3	7,105.7	7,074.9	7,027.8	6,983.7	6,899.0	6,917.2	6,721.8	6,432.9	6,168.1	6,120.1	6,185.6
		JNGI2014	8,377.2	8,235.5	8,163.1	8,091.0	7,922.6	7,701.8	7,496.2	7,358.8	7,258.1	7,202.0	7,146.6	7,078.0	7,024.0	6,954.3	6,887.5	6,779.6	6,774.4	6,553.8	6,323.8	6,132.7	6,143.8	6,185.2
		difference	*0.26%*	*0.26%*	*0.26%*	*0.25%*	*0.25%*	*0.25%*	*0.26%*	*0.26%*	*0.26%*	*0.15%*	*-0.07%*	*-0.39%*	*-0.72%*	*-1.05%*	*-1.38%*	*-1.73%*	*-2.06%*	*-2.50%*	*-1.70%*	*-0.57%*	*0.39%*	*-0.01%*
F. Field Burning of	CH_4	JNGI2013	100.7	100.2	93.4	96.0	92.8	94.0	90.0	85.6	81.8	78.7	77.1	75.5	71.5	68.2	66.7	65.5	65.1	63.5	61.5	58.4	55.9	55.8
Agricultural Residues		JNGI2014	100.7	100.2	93.4	96.0	92.8	94.0	90.0	85.6	81.8	78.7	77.1	75.5	71.5	68.2	66.7	65.5	65.1	63.5	61.5	58.4	56.0	56.1
		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%	0.11%	0.64%
	N_2O	JNGI2013	27.2	27.2	25.6	26.3	25.5	25.8	24.8	23.8	23.0	22.2	21.8	21.3	20.2	19.3	18.8	18.5	18.4	17.9	17.2	16.3	15.5	15.4
		JNGI2014	27.2	27.2	25.6	26.3	25.5	25.8	24.8	23.8	23.0	22.2	21.8	21.3	20.2	19.3	18.8	18.5	18.4	17.9	17.2	16.3	15.5	15.6
		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%*	*0.35%*	*1.22%*
4. Total	GHG	JNGI2013	31,565.6	31,514.2	31,485.6	31,407.1	30,991.1	30,360.2	29,710.7	29,071.3	28,628.5	28,209.2	27,937.7	27,665.8	27,418.6	27,183.4	26,992.7	26,825.7	26,790.1	26,492.0	26,267.6	25,960.2	25,882.6	25,758.1
		JNGI2014	29,134.7	29,116.6	29,124.1	29,103.6	28,749.2	28,166.2	27,546.4	26,941.2	26,523.2	26,152.9	25,952.0	25,779.0	25,620.4	25,471.3	25,360.7	25,263.2	25,296.8	25,067.2	24,786.7	24,404.6	24,209.7	24,026.0
		difference	*-7.70%*	*-7.61%*	*-7.50%*	*-7.33%*	*-7.23%*	*-7.23%*	*-7.28%*	*-7.33%*	*-7.35%*	*-7.29%*	*-7.11%*	*-6.82%*	*-6.56%*	*-6.30%*	*-6.05%*	*-5.82%*	*-5.57%*	*-5.38%*	*-5.64%*	*-5.99%*	*-6.46%*	*-6.72%*

Table 10-6 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Land use, land-use change and forestry sector)

5. Land Use, Land-Use Change and Forestry [Gg-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
A. Forest Land	CO_2	JNGI2013	-78,590.1	-85,944.0	-86,300.3	-86,649.3	-86,994.4	-87,340.3	-91,312.6	-91,153.9	-90,992.7	-90,833.1	-90,672.5	-90,514.5	-90,354.0	-99,127.0	-98,612.9	-92,050.4	-86,496.3	-85,282.0	-81,366.7	-77,894.6	-81,313.6	-78,091.3
		JNGI2014	-78,562.7	-85,920.9	-86,284.8	-86,636.9	-86,982.8	-87,329.7	-91,302.4	-91,144.8	-90,983.3	-90,824.4	-90,663.9	-90,507.4	-90,347.0	-99,122.2	-98,608.7	-92,469.2	-86,597.3	-85,331.3	-80,334.7	-75,674.8	-75,942.2	-77,917.6
		difference	*-0.03%*	*-0.03%*	*-0.02%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*-0.01%*	*0.00%*	*0.00%*	*0.45%*	*0.12%*	*0.06%*	*-1.27%*	*-2.85%*	*-6.61%*	*-0.22%*
	CH_4	JNGI2013	8.5	6.4	4.4	24.2	17.9	8.7	28.7	34.5	10.7	5.3	7.8	12.4	20.6	3.9	12.1	9.2	2.4	2.0	21.7	8.6	4.1	5.4
		JNGI2014	8.5	6.4	4.4	24.2	17.9	8.7	28.7	34.5	10.7	5.3	7.8	12.4	20.6	3.9	12.1	9.2	2.4	2.0	21.7	8.6	4.1	5.4
		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%*
	N_2O	JNGI2013	0.9	0.6	0.4	2.5	1.8	0.9	2.9	3.5	1.1	0.5	0.8	1.3	2.1	0.4	1.2	0.9	0.2	0.2	2.2	0.9	0.4	0.5
		JNGI2014	1.7	1.5	1.3	3.3	2.6	1.6	3.6	4.2	1.8	1.2	1.5	1.9	2.8	1.1	1.9	1.6	1.0	0.9	2.7	1.4	1.0	1.1
		difference	*100.62%*	*126.37%*	*182.21%*	*34.64%*	*45.41%*	*84.57%*	*24.97%*	*19.91%*	*62.09%*	*127.77%*	*87.66%*	*53.31%*	*32.17%*	*175.96%*	*54.79%*	*71.86%*	*289.40%*	*314.71%*	*21.49%*	*56.89%*	*136.53%*	*101.27%*
B. Cropland	CO_2	JNGI2013	3,662.8	2,942.4	3,027.4	2,338.9	2,302.4	2,262.7	2,134.0	2,044.0	2,051.9	2,014.6	1,867.6	1,808.1	1,772.7	1,769.1	1,731.2	1,772.6	1,786.7	1,745.3	1,724.8	1,749.8	1,950.6	1,781.1
		JNGI2014	4,188.2	3,209.3	3,296.0	2,421.8	2,372.6	2,322.1	2,170.0	2,066.4	2,071.1	2,026.1	1,867.2	1,803.4	1,766.0	1,760.1	1,720.2	1,754.4	1,766.9	1,844.4	1,715.8	1,861.1	1,757.8	1,709.1
		difference	*14.35%*	*9.07%*	*8.87%*	*3.55%*	*3.05%*	*2.63%*	*1.69%*	*1.10%*	*0.94%*	*0.57%*	*-0.02%*	*-0.26%*	*-0.38%*	*-0.51%*	*-0.64%*	*-1.03%*	*-1.11%*	*5.68%*	*-0.52%*	*6.36%*	*-9.88%*	*-4.04%*
	N_2O	JNGI2013	70.3	65.8	62.3	58.2	54.1	49.0	43.7	38.3	35.1	32.2	28.9	25.9	22.1	19.3	15.9	13.2	11.5	10.1	8.8	7.1	5.6	4.8
		JNGI2014	70.3	65.8	62.3	58.2	54.1	49.0	43.7	38.3	35.1	32.2	28.9	25.9	22.1	19.3	15.9	13.2	11.5	10.2	8.9	7.2	5.7	4.9
		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%*	*0.97%*	*1.09%*	*2.27%*	*1.39%*	*2.09%*
C. Grassland	CO_2	JNGI2013	-266.0	-340.1	-294.8	-359.3	-332.5	-309.0	-297.1	-276.8	-254.2	-240.9	-242.9	-232.9	-212.4	-194.3	-176.9	-160.0	-161.9	-146.5	-139.3	-118.0	-57.0	-90.2
		JNGI2014	-231.0	-341.2	-295.2	-386.8	-361.9	-339.9	-331.3	-312.9	-290.5	-278.2	-281.9	-272.3	-252.1	-234.2	-216.9	-200.7	-201.8	-169.2	-161.4	-139.5	-111.9	-133.1
		difference	*-13.14%*	*0.32%*	*0.15%*	*7.67%*	*8.84%*	*9.99%*	*11.53%*	*13.02%*	*14.27%*	*15.49%*	*16.04%*	*16.92%*	*18.68%*	*20.50%*	*22.61%*	*25.42%*	*24.66%*	*15.47%*	*15.86%*	*18.23%*	*96.14%*	*47.49%*
D. Wetlands	CO_2	JNGI2013	68.1	62.4	201.4	114.7	97.4	306.7	557.5	108.3	444.3	427.9	408.6	378.9	94.9	64.1	58.7	15.7	23.4	27.8	16.4	23.8	86.6	60.1
		JNGI2014	90.9	81.2	255.0	141.6	117.3	360.3	639.6	121.5	487.1	458.8	428.7	389.2	95.5	63.2	56.8	14.7	22.0	56.7	34.5	73.4	51.5	44.0
		difference	*33.58%*	*30.02%*	*26.64%*	*23.44%*	*20.41%*	*17.51%*	*14.73%*	*12.15%*	*9.63%*	*7.22%*	*4.92%*	*2.72%*	*0.60%*	*-1.43%*	*-3.39%*	*-6.14%*	*-5.92%*	*104.22%*	*110.01%*	*207.97%*	*-40.53%*	*-26.84%*
E. Settlements	CO_2	JNGI2013	3,532.1	4,371.4	5,049.8	3,535.6	2,692.4	2,665.6	2,048.4	1,747.1	1,779.5	1,444.7	1,120.7	928.6	67.3	-22.9	4.8	365.2	738.8	449.7	410.4	755.2	2,888.4	411.1
		JNGI2014	5,115.7	6,046.6	6,728.2	4,663.1	3,515.1	3,376.8	2,563.2	2,145.8	2,108.7	1,678.9	1,279.8	1,029.4	120.1	2.9	9.4	314.9	671.7	515.5	578.7	766.6	1,292.3	156.2
		difference	*44.84%*	*38.32%*	*33.24%*	*31.89%*	*30.56%*	*26.68%*	*25.13%*	*22.82%*	*18.50%*	*16.21%*	*14.20%*	*10.86%*	*78.32%*	*-112.49%*	*96.68%*	*-13.75%*	*-9.08%*	*14.65%*	*41.01%*	*1.51%*	*-55.26%*	*-62.00%*
F. Other Land	CO_2	JNGI2013	1,430.9	1,600.9	1,355.7	1,665.0	1,600.9	1,458.6	1,374.3	1,713.1	1,397.5	1,480.9	1,170.2	1,267.3	1,153.1	964.6	949.7	974.5	750.8	571.8	890.6	1,108.5	420.5	237.6
		JNGI2014	1,950.1	2,130.1	1,772.5	2,128.9	2,027.5	1,837.1	1,693.9	2,038.6	1,659.4	1,704.9	1,350.5	1,440.7	1,274.9	1,053.9	1,004.8	1,000.3	794.2	310.2	328.5	319.1	341.4	295.5
		difference	*36.29%*	*33.05%*	*30.74%*	*27.86%*	*26.65%*	*25.95%*	*23.25%*	*19.00%*	*18.74%*	*15.12%*	*15.41%*	*13.69%*	*10.56%*	*9.26%*	*5.80%*	*2.64%*	*5.79%*	*-45.75%*	*-63.12%*	*-71.21%*	*-18.81%*	*24.38%*
G. Other	CO_2	JNGI2013	550.2	527.4	477.1	481.6	292.8	303.5	292.7	303.7	300.0	293.6	332.9	247.3	269.9	246.4	236.3	231.3	230.4	325.0	305.7	270.2	242.9	246.8
		JNGI2014	550.2	527.4	477.1	481.6	292.8	303.5	292.7	303.7	300.0	293.6	332.9	247.3	269.9	246.4	236.3	231.3	230.4	325.0	305.7	270.2	242.9	246.8
		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%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*
5. Total	GHG	JNGI2013	-69,532.3	-76,706.8	-76,416.6	-78,787.9	-80,267.4	-80,593.7	-85,127.5	-85,438.2	-85,226.7	-85,374.2	-85,977.9	-86,077.7	-87,163.7	-96,276.4	-95,779.8	-88,827.8	-83,113.9	-82,296.7	-78,125.3	-74,088.5	-75,771.6	-75,434.1
		JNGI2014	-66,817.9	-74,193.9	-73,983.2	-77,100.9	-78,944.9	-79,410.3	-84,198.3	-84,704.7	-84,599.9	-84,901.6	-85,648.4	-85,829.3	-87,027.2	-96,205.6	-95,768.4	-89,330.2	-83,298.9	-82,435.6	-77,499.6	-72,506.7	-72,357.4	-75,587.7
		difference	*-3.90%*	*-3.28%*	*-3.18%*	*-2.14%*	*-1.65%*	*-1.47%*	*-1.09%*	*-0.86%*	*-0.74%*	*-0.55%*	*-0.38%*	*-0.29%*	*-0.16%*	*-0.07%*	*-0.01%*	*0.57%*	*0.22%*	*0.17%*	*-0.80%*	*-2.13%*	*-4.51%*	*0.20%*

Table 10-7 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 (Waste sector)

6. Waste [Gg-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
A. Solid Waste	CH_4	JNGI2013	7,637.4	7,565.7	7,529.6	7,396.6	7,284.1	7,070.2	6,869.8	6,641.4	6,370.4	6,114.0	5,875.9	5,616.5	5,354.6	5,090.7	4,824.7	4,567.7	4,300.4	4,053.4	3,758.3	3,517.3	3,286.1	3,092.8
Disposal on Land		JNGI2014	7,637.4	7,565.7	7,529.6	7,396.6	7,284.1	7,070.2	6,869.8	6,641.4	6,370.4	6,114.0	5,874.9	5,615.9	5,354.2	5,090.6	4,824.7	4,567.8	4,300.6	4,053.6	3,767.4	3,524.7	3,292.3	3,095.7
		difference	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*-0.02%*	*-0.01%*	*-0.01%*	*0.00%*	*0.00%*	*0.00%*	*0.00%*	*0.01%*	*0.24%*	*0.21%*	*0.19%*	*0.09%*
B. Waste-water	CH_4	JNGI2013	2,402.3	2,343.8	2,325.4	2,284.6	2,239.5	2,207.2	2,174.7	2,143.2	2,099.0	2,074.5	2,042.8	1,849.2	1,801.1	1,765.9	1,732.1	1,683.8	1,652.0	1,611.2	1,591.6	1,545.1	1,517.6	1,517.6
Handling		JNGI2014	2,402.3	2,343.8	2,325.4	2,284.6	2,239.5	2,207.2	2,174.7	2,143.2	2,099.0	2,074.4	2,042.8	1,849.2	1,803.4	1,765.1	1,732.2	1,684.7	1,652.0	1,611.8	1,591.6	1,545.1	1,516.8	1,491.4
		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%*	*0.13%*	*-0.05%*	*0.01%*	*0.05%*	*0.00%*	*0.04%*	*0.00%*	*0.00%*	*-0.05%*	*-1.72%*
	N_2O	JNGI2013	1,255.5	1,281.7	1,271.4	1,296.9	1,286.0	1,306.5	1,304.6	1,316.3	1,305.2	1,274.9	1,243.5	1,270.9	1,272.4	1,279.0	1,281.5	1,262.7	1,273.6	1,252.0	1,252.5	1,235.9	1,221.6	1,221.5
		JNGI2014	1,255.5	1,281.7	1,271.4	1,296.9	1,286.0	1,306.5	1,304.6	1,316.3	1,305.2	1,274.9	1,243.5	1,270.9	1,274.7	1,278.1	1,281.6	1,263.3	1,273.6	1,252.2	1,252.5	1,235.9	1,221.3	1,212.9
		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%*	*0.17%*	*-0.07%*	*0.01%*	*0.04%*	*0.00%*	*0.02%*	*0.00%*	*0.00%*	*-0.02%*	*-0.71%*
C. Waste Incineration	CO_2	JNGI2013	12,263.0	12,298.1	13,325.3	13,093.3	15,567.0	15,866.6	16,310.4	16,892.0	16,911.1	16,677.3	16,837.9	15,615.4	15,059.2	15,055.3	14,517.6	13,984.5	13,132.8	12,976.4	14,604.8	11,922.5	12,452.1	12,390.5
		JNGI2014	12,263.0	12,298.1	13,325.3	13,093.3	15,567.0	15,866.6	16,310.4	16,892.0	16,911.1	16,677.3	16,837.9	15,615.4	15,059.2	15,055.3	14,517.6	13,984.5	13,132.8	12,976.4	14,605.5	11,922.4	12,451.8	11,955.5
		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%*	*-3.51%*
	CH_4	JNGI2013	13.5	13.1	13.4	13.4	14.5	14.9	15.2	14.7	14.5	14.0	13.3	12.6	19.5	16.8	15.4	14.3	13.3	12.2	11.8	10.5	9.7	9.7
		JNGI2014	13.5	13.1	13.4	13.4	14.5	14.9	15.2	14.7	14.5	14.0	13.3	12.6	19.5	16.8	15.4	14.3	13.3	12.2	11.8	10.5	9.7	9.6
		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%*	*-0.25%*	*-0.80%*
	N_2O	JNGI2013	1,493.0	1,534.8	1,673.2	1,674.2	1,838.4	1,981.4	2,107.4	2,182.4	2,187.1	2,260.9	2,241.5	2,169.6	1,987.5	1,984.8	1,974.9	2,042.4	1,917.5	1,762.2	1,693.8	1,633.4	1,580.3	1,565.9
		JNGI2014	1,493.0	1,534.8	1,673.2	1,674.2	1,838.4	1,981.4	2,107.4	2,182.4	2,187.1	2,260.9	2,241.5	2,169.6	1,987.5	1,984.8	1,974.9	2,042.4	1,917.5	1,762.2	1,693.8	1,633.4	1,577.4	1,585.4
		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%*	*-0.18%*	*1.25%*
D. Other	CO_2	JNGI2013	702.8	686.4	698.9	680.7	701.9	667.8	640.5	655.2	609.1	652.6	655.9	630.5	577.0	516.5	506.7	506.8	522.4	561.2	530.4	513.7	526.9	522.3
		JNGI2014	702.8	686.4	698.9	680.7	701.9	667.8	640.5	655.2	609.1	652.6	655.9	630.5	577.0	516.5	506.7	506.8	522.4	561.2	530.4	513.7	526.9	524.1
		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%*	*0.35%*
	CH_4	JNGI2013	111.8	102.6	102.9	102.9	112.6	106.4	98.9	99.4	103.2	103.8	96.2	97.5	98.7	108.4	113.2	126.0	129.6	156.4	156.7	172.2	190.0	140.5
		JNGI2014	92.0	89.1	89.5	90.0	88.7	89.1	89.5	90.6	89.8	90.4	91.5	92.7	114.9	133.5	137.3	155.4	161.1	156.5	175.2	176.0	153.2	169.0
		difference	*-17.73%*	*-13.16%*	*-13.06%*	*-12.52%*	*-21.19%*	*-16.21%*	*-9.52%*	*-8.81%*	*-13.00%*	*-12.91%*	*-4.88%*	*-4.88%*	*16.46%*	*23.23%*	*21.27%*	*23.38%*	*24.23%*	*0.05%*	*11.76%*	*2.24%*	*-19.36%*	*20.22%*
	N_2O	JNGI2013	99.1	90.9	91.2	91.2	99.7	94.2	87.6	88.0	91.4	92.0	85.2	86.4	87.4	96.0	100.3	111.6	114.8	138.6	138.8	152.5	168.3	124.5
		JNGI2014	81.5	78.9	79.3	79.8	78.6	78.9	79.3	80.3	79.6	80.1	81.0	82.1	101.8	118.3	121.6	137.6	142.7	138.6	155.1	155.9	135.7	149.7
		difference	*-17.73%*	*-13.16%*	*-13.06%*	*-12.52%*	*-21.19%*	*-16.21%*	*-9.52%*	*-8.81%*	*-13.00%*	*-12.91%*	*-4.88%*	*-4.88%*	*16.46%*	*23.23%*	*21.27%*	*23.38%*	*24.23%*	*0.05%*	*11.76%*	*2.24%*	*-19.36%*	*20.22%*
6. Total	GHG	JNGI2013	25,978.4	25,917.2	27,031.4	26,633.7	29,143.8	29,315.2	29,609.1	30,032.6	29,691.1	29,263.9	29,092.2	27,348.6	26,257.4	25,913.5	25,066.3	24,299.7	23,056.5	22,523.6	23,738.9	20,702.9	20,952.6	20,585.4
		JNGI2014	25,941.0	25,891.7	27,006.0	26,609.4	29,098.8	29,282.7	29,591.3	30,016.1	29,665.7	29,238.6	29,082.4	27,339.0	26,292.2	25,959.1	25,112.0	24,356.7	23,115.9	22,524.8	23,783.4	20,717.6	20,885.1	20,193.3
		difference	*-0.14%*	*-0.10%*	*-0.09%*	*-0.09%*	*-0.15%*	*-0.11%*	*-0.06%*	*-0.05%*	*-0.09%*	*-0.09%*	*-0.03%*	*-0.03%*	*0.13%*	*0.18%*	*0.18%*	*0.23%*	*0.26%*	*0.01%*	*0.19%*	*0.07%*	*-0.32%*	*-1.90%*

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 2008 to 2011 decreased by 0.17%, increased by 0.003%, decreased by 0.62%, and decreased by 1.07% respectively (Table 10-8).

Table 10-8 Comparison of emissions and removals in the inventories submitted in 2013 and 2014 for KP-LULUCF activities

KP-LULUCF activities [Gg-CO_2 eq.]

Activity	Gas		1990	2008	2009	2010	2011
Afforestation and Reforestation	CO_2	JNGI2013	-	-426.9	-441.3	-456.0	-462.0
		JNGI2014	-	-426.3	-448.0	-469.7	-482.3
		difference	-	*-0.13%*	*1.52%*	*2.99%*	*4.37%*
	CH_4	JNGI2013	-	0.0265	0.0108	0.0053	0.0069
		JNGI2014	-	0.0270	0.0111	0.0056	0.0073
		difference	-	*1.87%*	*3.23%*	*5.64%*	*5.58%*
	N_2O	JNGI2013	-	0.00269	0.00110	0.00054	0.00070
		JNGI2014	-	0.00274	0.00113	0.00057	0.00074
		difference	-	*1.87%*	*3.23%*	*5.64%*	*5.58%*
Deforestation	CO_2	JNGI2013	-	2,641.6	3,273.9	5,064.4	2,019.1
		JNGI2014	-	2,164.6	2,643.4	3,033.0	1,630.1
		difference	-	*-18.06%*	*-19.26%*	*-40.11%*	*-19.26%*
	N_2O	JNGI2013	-	3.09	3.21	3.04	2.86
		JNGI2014	-	3.13	3.32	3.02	2.84
		difference	-	*1.48%*	*3.59%*	*-0.75%*	*-0.67%*
Forest Management	CO_2	JNGI2013	-	-46,932.1	-48,738.4	-53,289.0	-52,609.9
		JNGI2014	-	-46,378.4	-48,102.7	-50,935.0	-51,643.1
		difference	-	*-1.18%*	*-1.30%*	*-4.42%*	*-1.84%*
	CH_4	JNGI2013	-	12.871	5.268	2.635	3.482
		JNGI2014	-	12.864	5.264	2.633	3.480
		difference	-	*-0.06%*	*-0.09%*	*-0.07%*	*-0.04%*
	N_2O	JNGI2013	-	1.3	0.5	0.3	0.4
		JNGI2014	-	1.8	1.0	0.8	0.9
		difference	-	*36.23%*	*92.92%*	*214.49%*	*155.60%*
Revegetation	CO_2	JNGI2013	-77.9	-1,080.0	-1,110.4	-1,128.2	-1,141.5
		JNGI2014	-77.8	-1,079.7	-1,110.9	-1,128.7	-1,142.1
		difference	*-0.06%*	*-0.03%*	*0.04%*	*0.04%*	*0.05%*
Total		JNGI2013	-77.9	-45,780.0	-47,007.2	-49,802.9	-52,187.7
		JNGI2014	-77.8	-45,702.0	-47,008.5	-49,493.8	-51,630.0
		difference	*-0.06%*	*-0.17%*	*0.003%*	*-0.62%*	*-1.07%*

10.3. Implication for Emission Trends, including Time Series Consistency

Table 10-9 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 2013submission (JNGI 2013) and the 2014 submission (JNGI 2014) is made through the comparison of values between the base year and FY2011.

10.3.1. GHG Inventory

Total emissions excluding the LULUCF sector in the 2014 submission increased by approximately 0.5 million tons (in CO_2 equivalents) and increased by 0.04 percentage points, compared to the data reported in the previous submission.

Table 10-9 Comparison of increase and decrease from the base year, between the inventories submitted in 2012 and 2014 excluding LULUCF sector

		Trend [Mt-CO_2 eq.]			Trend [%]		
		JNGI2013	JNGI2014	Difference	JNGI2013	JNGI2014	Difference
CO_2	1)	99.5	99.5	-0.1	8.7%	8.7%	0.0%
CH_4	1)	-11.8	-12.1	-0.3	-36.8%	-37.4%	-0.6%
N_2O	1)	-10.1	-9.2	0.8	-31.4%	-31.1%	0.3%
HFCs	2)	0.2	0.2	-0.02	1.0%	0.9%	-0.1%
PFCs	2)	-11.3	-11.3	0.0	-78.9%	-78.9%	0.0%
SF_6	2)	-15.3	-15.3	0.0	-90.3%	-90.3%	0.0%
Total	3)	51.3	51.7	0.5	4.1%	4.1%	0.04%

1) Comparison of emissions between FY1990 and FY2011
2) Comparison of emissions between CY1995 and CY2011
3) Comparison of emissions between the base year of the Kyoto Protocol (CO_2, CH_4, N_2O: FY1990, HFCs, PFCs, SF_6: CY1995) and 2011

10.4. Recalculations and improvement plan, including response to the review process

10.4.1. Improvements after submission of inventory

The major improvements carried out since submission of the 2013 inventory are listed below.

10.4.1.1. Methodology for estimating emissions and removals of GHGs

Changed calculation methods are provided in Table 10-10.

10.4.1.1.a. GHG Inventory

Table 10-10 Changes in estimation methods

Sector and category		Changes in estimation methods
1.A.3.	CO_2 Emissions from Transport (Mobile Combustion)	The estimated natural gas fuel consumption by natural gas-powered vehicle and the coal consumption by steam locomotives from FY1990 has become available on the *General Energy Statistics*, therefore the emissions after GHG Inventory submitted in 2014 are reported as the gaseous fuel and solid fuel in this category.
1.A.3.b	CH_4 and N_2O emissions from road transportation	CH_4 and N_2O emissions from FY1990 to FY2011 were recalculated due to the updates and the improvements of the actual measurement data for the emission factors of gasoline and LPG vehicles. CH_4 and N_2O emissions from FY1994 to FY2011 were recalculated due to the updates of the actual measurement data for the emission factors of diesel passenger vehicles and diesel regular cargo trucks. As for activity data, the car-mileage data of each vehicle type had been transferred to Survey on Motor Vehicle Fuel Consumption and continuity adjustment with previous data was done, thus CH_4 and N_2O emissions from FY2010 to FY2011 were recalculated.
1.A.3.b	CH_4 and N_2O emissions from natural gas-powered vehicles	The emissions from FY1990 to FY2011 were recalculated due to the elaboration work of the activity data, such as revising the number of the natural gas powered vehicles, from the total number of vehicles introduced in the past which does not consider the discarded vehicles, to the number of the vehicles actually registered.
1.A.3.b	CH_4 and N_2O emissions from motorcycles	CH_4 and N_2O emissions from FY2009 to FY2011 were recalculated due to the updates of the reduction rate of motorcycle operation due to rain or snow, and the CH_4 emissions from FY2007 to FY2011 were recalculated due to the improvement of the actual measurement data for emission factors of regulated motorcycles.
1.A.3.c	Railways	The GHG emissions from FY1990 to FY2012 were recalculated with the revision of the coal consumption data from FY1990 to FY2012
1.B.1.a.i.	Underground Mines	CH_4 recovery from coal mining from FY 1990 to FY 2011 was recalculated from “NE” to estimates. And CH_4 total emissions from coal mining were recalculated.
2.B.4.	Silicon carbide production	The AD was revised for CH_4 emissions.
2.C.	Metal production	F-gas emissions were newly estimated for the years 1990 to 1994.

Sector and category		Changes in estimation methods
2.E.	Production of halocarbons and SF_6	Emissions were newly estimated for the years 1990 to 1994.
2.F.	Consumption of halocarbons and SF_6	Emissions were newly estimated for the years 1990 to 1994.
4.A.	Enteric fermentation	For dairy cattle, milk yield for all years were revised. Therefore, emissions from dairy cattle were revised.
4.B.	Livestock manure management	For sun drying and piling for poultry, and purification for swine, new emission factors were developed. Therefore, emissions for all the years were revised. In addition, applying years of “percentage of manure management by type of animal” and “proportion of separated and mixed treatment of manure, by type of livestock” were revised. (Interpolation were applied from FY2000 to FY2008.) Therefore, emissions from FY1999 to FY2009 were revised.
4.D.1.	Agricultural soils/ Direct soil emission/ Synthetic Fertilizers	The amount of synthetic fertilizer applied to agricultural soil was revised (amount of synthetic fertilizer applied to forest was subtracted form total amount of synthetic fertilizer). Therefore, emissions for all years were revised
5.A.1.	Forest land remaining Forest land	Areas of forest land remaining forest land were revised, and Forest Registers were updated. As a result, carbon stock changes in living biomass, dead organic matter and soils were recalculated.
5.A.2.	Land converted to Forest land	Areas of land converted to forest land since 2007 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils were recalculated. In addition, carbon stock changes in living biomass in orchard converted to forest land were recalculated because of revision of parameter.
5.B.1.	Cropland remaining Cropland	Areas of cropland remaining cropland were recalculated due to recalculation of land converted to cropland. As a result, carbon stock changes in mineral soils in this category were recalculated.
5.B.2.	Land converted to Cropland	Areas of forest land converted to cropland since 2007, biomass accumulations in forest land before conversion from 1990 to 2011 and carbon stocks in dead organic matter and soils in forest land before conversion from 2008 to 2011 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated.
5.C.1.	Grassland remaining Grassland	The area of grassland remaining grassland in FY2011 was revised because the area of wild land in FY2011 was revised. In addition, reporting of carbon pools in wild land was changed from “NE” to “NA”. Furthermore, CO_2 emissions from organic soils in pasture land were changed from estimates to “NO”.
5.C.2.	Land converted to Grassland	Areas of forest land converted to grassland since 2007, biomass accumulations in forest land before conversion from 1990 to 2011 and carbon stocks in dead organic matter and soils in forest land before conversion from 2008 to 2011 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated. In addition, carbon stock changes in living biomass in orchard converted to grassland were recalculated because of revision of parameter.
5.D.1.	Wetlands remaining Wetlands	Areas of urban parks in river banks and green areas along rivers and erosion control were revised. As a result, the areas of wetlands remaining wetlands were recalculated.

Sector and category		Changes in estimation methods
5.D.2.	Land converted to Wetlands	Areas of forest land converted to wetlands since 2007, biomass accumulations in forest land before conversion from 1990 to 2011 and carbon stocks in dead organic matter and soils in forest land before conversion from 2008 to 2011 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated. In addition, carbon stock changes in living biomass in orchard converted to wetlands were recalculated because of revision of parameter.
5.E.1.	Settlements remaining Settlements	Areas of settlements remaining settlements were recalculated due to recalculation of land converted to settlements. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated.
5.E.2.	Land converted Settlements	Areas of forest land converted to settlements since 2007, biomass accumulations in forest land before conversion from 1990 to 2011 and carbon stocks in dead organic matter and soils in forest land before conversion from 2008 to 2011 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated. In addition, carbon stock changes in living biomass in orchard converted to settlements were recalculated because of revision of parameter.
5.F.1.	Other land remaining Other land	The statistical data on the total national land was changed, and areas other than other land remaining other land were recalculated. As a result, the land areas for this category were recalculated.
5.F.2.	Land converted to Other land	Areas of forest land converted to other land since 2007, biomass accumulations in forest land before conversion from 1990 to 2011 and carbon stocks in dead organic matter and soils in forest land before conversion from 2008 to 2011 were revised. As a result, carbon stock changes in living biomass, dead organic matter and soils in this category were recalculated. In addition, carbon stock changes in living biomass in orchard converted to other land were recalculated because of revision of parameter.
5(I)	Direct N_2O emissions from N fertilization	Amount of N fertilization to forest land was separated from agriculture sector, and direct N_2O emissions from N fertilization in forest land were reported in LULUCF sector. Hence, reporting this subcategory was changed from “IE” to N_2O emission estimates.
5(III)	N_2O emissions from disturbance associated with land-use conversion to cropland	Areas of forest land converted to cropland were revised. Accordingly, the N_2O emissions from this category were recalculated.
5(IV)	CO_2 emissions from agricultural lime application	The FY2011 emissions recalculated because amount of fossil seashell powder applied on FY2011 was revised.
6.A.1.	Emissions from Managed Landfill Sites	CH_4 emissions from tsunami sediment were estimated because the amount of disaster waste caused by the Great East Japan Earthquake was identified.
6.D.1.	Emissions from Composting of Organic Waste	CH_4 and N_2O emissions from composting of organic waste were recalculated because the amount of additives to be mixed during the process of composting sewage sludge was identified.
6.D.1.	Emissions from Composting of Organic Waste	CH_4 and N_2O emissions from composting of organic waste were recalculated because the data sources for the amount of composted animal and plant residues were reviewed and updated.

10.4.1.1.b. KP-LULUCF Inventory

Table 10-11 Changes in estimation methods

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 were recalculated.
Forest Management (FM)	FM areas were recalculated due to revision of ARD areas mention above. As a result, carbon stock changes in all carbon pools under the ARD activities were recalculated. In addition, amount of N fertilization to forest land was separated from agriculture sector, and direct N_2O emissions from N fertilization in forest land were reported in LULUCF sector. Hence, reporting this subcategory was changed from “IE” to N_2O emission estimates.
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 were also recalculated. In addition, CO_2 emissions from lime application in RV were also recalculated.

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 UNFCCC-ERT recommendations are summarized below. See relative sections for details.

The Committee for Greenhouse Gas Estimation Methods (see “Committee for Greenhouse Gas Estimation Methods Annex” (A6.1.3.5)) address all the recommendations raised by ERT, and tireless efforts has been made to tackle the issues and improve a national GHG inventory with due consideration of the priority.

Table 10-12 Summary of improvements made to national inventory and current status of UNFCCC-ERT recommendations

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Energy	Provide additional information on the drivers of the trends for the energy sector in particular, information on electricity consumption, the quantity of oil refined, vehicle statistics and fuel use in transport, household numbers and occupancy levels as provided to the ERT during the review. (ARR2013 para 21)	The explanation was included in this NIR.	NIR Chapter 3 (3.2)
Energy /Comparison of the reference approach with the sectoral approach and international statistics	Complete the documentation box in CRF table 1.A (c), briefly explaining the differences between the two approaches and referencing the information provided in annex 4 to the NIR. (ARR2013 para 23)	The explanation was included in this CRF table 1.A (c).	CRF Table 1.A(c)
Energy /Comparison of the reference approach with the sectoral approach and international statistics	Address the inconsistency in the reporting of coal production, which is included in CRF table 1.B but not in CRF table 1.A (b), by providing coal production data in CRF table 1.A (b). (ARR2013 para 24)	If the indigenous coal production for the market were to restart and the data were to be available on the public statistics, using the data for the *General Energy Statistics* would be considered.	
Energy /International bunker fuels	Provide additional information on the method used to derive the country-specific EF for jet kerosene. (ARR2013 para 26)	Additional information to derive the country-specific EF for jet kerosene was provided.	NIR Chapter 3 (3.2.10)
Energy /Feedstocks and non-energy use of fuels	Report the CO_2 emissions from solid fuels used as feedstock under the industrial processes sector. (ARR2013 para 27)	In 2013, the Committee for GHG Emissions Estimation Methods - Breakout group on Energy and IP started consideration of how to separate out emissions that are to be reported under IP in the most appropriate and best suited way to the Japanese circumstance, and the process is still on-going.	NIR Chapter 3 (3.2.11)
Energy /Feedstocks and non-energy use of fuels	Provide additional information clearly showing the feedstock amounts for each fuel type and the corresponding category where emissions occur or carbon is stored, consistent with the information provided in CRF table 1.A (d), and revise tables 3-12, 3-13, 3-28 and 3-31 of the NIR, clarifying the references to fuel codes “#9xxx.” (ARR2013 para 28)	The explanation was included in this NIR.	NIR Chapter 3 (3.2.11)
Energy/Stationary combustion: liquid, solid and gaseous fuels - CH_4 and N_2O (1.A.)	Provide in the NIR a table showing all country-specific CH_4 and N_2O EFs, by individual fuel, category and furnace type, elaborating on the information currently provided in NIR table 3-10. (ARR2013 para 30)	The explanation was included in this NIR.	NIR Chapter 3 (3.2.2)

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Energy/Stationary combustion: liquid, solid and gaseous fuels - CH_4 and N_2O (1.A.)	Provide additional information on the actual measurements recorded and on how these measurement data are used to derive the EFs. (ARR2013 para 30)	The explanation was included in this NIR.	NIR Annex 3 (A3.1)
Energy/Stationary combustion: liquid, solid and gaseous fuels - CH_4 and N_2O (1.A.)	Provide additional information to transparently justify the validity of the measurement data and the appropriateness of these measurements to current boiler types/technologies. (ARR2013 para 31)	The explanation was included in this NIR.	NIR Annex 3 (A3.1)
Energy/Road transportation: natural gas – CO_2, CH_4 and N_2O (1.A.3.b.)	Collect AD on the natural gas consumed by vehicles for the historical years 1990–2009 or estimate the fuel consumed using the annual vehicle–kilometre data reported in NIR table 3-22 and report these AD and all emissions for all years of the time series under road transportation. (ARR2013 para 33)	AD and all emissions for all years of the time series were reported under road transportation.	NIR Chapter 3 (3.2.5)
Energy/Railways: solid fuels - CO_2 (1.A.3.c.)	Report the coal consumption AD and the associated CO_2 emissions under railways in order to improve transparency and enable the comparability of the EFs for all gases, while ensuring that emissions are not double counted under commercial/institutional. (ARR2013 para 34)	The coal consumption AD and the associated CO_2 emissions were reported under railways.	NIR Chapter 3 (3.2.5)
Energy/Other transportation: natural gas - CO_2, CH_4 and N_2O (1.A.3.)	Report the AD and emissions associated with fuel used for pipeline transport under other transportation or report the AD and emissions using a notation key in CRF table 1.A (a) and provide a description of the approach taken in. (ARR2013 para 35)	The AD and emissions were reported using a notation key in CRF table 1.A (a).	CRF Table 1.A(a)
Industrial processes/General	Clearly provide descriptions of all assumptions and expert judgment used and include information explaining the years for which the estimates have been calculated with the descriptions of the AD. (ARR2013 para 38)	General explanations on expert judgments including assumptions made, and more specific explanations on issues raised during review have been added. Also, the fact that all years have been estimated for, and where in the NIR related AD and emissions are shown have been described.	NIR Chapter 4 (Chapter top, 4.3.5.2 Footnote 1, 4.7.4.1 and 4.7.4.2 under Tables etc.)
Industrial processes/General	Specify which EFs are country-specific and which are IPCC defaults, especially for the key categories. (ARR2013 para 39)	The differences between country-specific/IPCC default values have been clarified for the EFs.	NIR Chapter 4 (Sections on EFs for each key-category)

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Industrial processes/General	Allocate CO_2 emissions from industrial activities in line with the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. (ARR2013 para 40)	In 2013, the Committee for GHG Emissions Estimation Methods - Breakout group on Energy and IP started consideration of how to separate out emissions that are to be reported under IP in the most appropriate and best suited way to the Japanese circumstance, and the process is still on-going.	-
Industrial processes/Consumption of halocarbons and SF6 - HFCs, PFCs and SF_6 (2.F.)	Report the missing estimates of F-gas emissions for the years 1990-1994 in the annual submission and explain the methodologies used to calculate the estimates. (ARR2013 para 42)	Emissions were newly estimated for the years 1990 to 1994.	NIR Chapter 4 (4.4.3 to 4.7.9) CRF Table 2(II).Fs1, 2 etc.)
Industrial processes/Consumption of halocarbons and SF6 - HFCs, PFCs and SF_6 (2.F.)	Include information on why all potential HFC emissions are reported under the category other non-specified and how the data collection has been performed. (ARR2013 para 43)	Explanations were newly added for potential emissions of F-gases.	NIR Chapter 4 (4.7.10)
Industrial processes/Consumption of halocarbons and SF_6 - HFCs, PFCs and SF_6 (2.F.)	Replace the "zero" values reported for some HFCs with the correct notation keys. (ARR2013 para 44)	The values reported as zero are modified to appropriate notation keys.	CRF Table 2(II).Fs1, 2)
Industrial processes/Aluminium production - PFCs (2.C.3.)	Report the missing estimates of PFC emissions for the years 1990-1994 and explain the methodologies used to calculate the estimates. (ARR2013 para 46)	PFC emissions were newly estimated for the years 1990 to 1994.	NIR Chapter 4 (4.4.3)
Agriculture/ Manure Management (4.B)	Provide additional information on the calculations and data sources used. (ARR 2013 para 51)	Descriptions of estimation method for major emission factors and results of comparison between Japan's EFs and default values were added in the NIR.	NIR Chapter 6 (6.3.1.b. and 6.3.1.d.)
Agriculture/ Manure Management (4.B)	Provide an explanation in the NIR of how the CH_4 emissions from pit storage and CH_4 fermentation for dairy cattle have been derived. (ARR 2013 para 52)	Descriptions of development for EFs and trend of EFs were added in the NIR.	NIR Chapter 6 (6.3.1.b.)
Agriculture/ Manure Management (4.B)	Increase the transparency of the method used to estimate CH_4 emissions from manure management, particularly by providing additional information on the calculations and data sources used for the EFs reported in NIR tables 6-13 and 6-15 and include the MCF values in CRF table 4.B (a). (ARR 2013 para 53)	Description of MCF values and development for EFs were added in the NIR.	NIR Chapter 6 (6.3.1.b.)

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Agriculture/ Manure Management (4.B)	Explain the step-wise increase in the percentage of AWMS by type of animal for all AWMS and consider using interpolation to avoid this step-wise change in manure management as the changes occur gradually. (ARR 2013 para 54)	Responding to the recommendation, the estimation method for 2000 to 2008 was revised (by using interpolation), and description was revised in the NIR.	NIR Chapter 6 (6.3.1.b.), CRF Table 4.B
Agriculture/ Manure Management (4.B)	Improve the description of the methodology used and provide additional information regarding the country-specific EFs for cattle livestock for pasture, range and paddock. (ARR 2013 para 55)	Descriptions of estimation method of EFs and results of comparison between Japan's EFs and default values were added in the NIR.	NIR Chapter 6 (6.3.1.b. and 6.3.1.d.)
Agriculture/ Enteric Fermentation (4.A)	Improve the explanations of the assumptions used for the livestock characterization (e.g. the proportion of the different age classes for dairy and non-dairy cattle). (ARR 2013 para 56)	Information were added in the NIR Table 6-2 (Categorization and assumptions underlying calculation of CH_4 emissions associated with enteric fermentation in cattle).	Table 6-2, NIR Chapter 6
Agriculture/ Enteric Fermentation (4.A)	Improve the description of the methodology used to derive the CH_4 EF and provide the results of the comparison with the tier 2 IPCC methodology. (ARR 2013 para 57)	Descriptions for the result of comparison between Japan's estimation method and IPCC Tier 2 method were added in the NIR.	NIR Chapter 6 (6.2.1.d.)
Agriculture/ Enteric Fermentation (4.A)	Provide additional information on the CH_4 EFs for sheep, goats and swine. (ARR 2013 para 58)	Information of EFs for sheep, goats and swine were added in the NIR.	NIR Chapter 6 (6.2.2.b.)
Agriculture/ Enteric Fermentation (4.A)	Check the high milk yield data to ensure the accuracy of the inventory, and report thereon in the NIR. (ARR 2013 para 59)	There was a mistake in the method of calculation for milk yield. Therefore, milk yield were corrected.	CRF Table4.A NIR Chapter 6 (6.2.1.)
LULUCF/General	Provide as much information as necessary to explain the trends, in chapter 2 of the NIR, and include this information in the overview section of chapter 7. (paragraph 64 in ARR 2013)	Information as necessary to explain the trends was added to the NIR.	NIR Chapter 7 (7.1), (7.4), (7.4.1)
LULUCF/General	Report a single matrix for the period 1990–2012. (paragraph 66 in ARR 2013)	A single matrix for the period 1990-2012 was added to the NIR.	NIR Chapter 7 Table7-3
LULUCF/General	If Japan has verifiable evidence that the activity does not occur, this should be reported in both the NIR and the CRF tables as "NO"; however, if there is no verifiable information to report negligible AD, then this should be reported as "very rare" in the NIR and either the emissions or the notation key "NE" should be reported in the CRF tables. (paragraph 67 in ARR	Reasons reported as "NO" in the CRF tables were added to the NIR.	NIR Chapter 7 (7.4.1), (7.5.2), (7.6.2), (7.11), (7.14)

	2013)		
Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
LULUCF/General	Provide information explaining why the area of organic soils under the LULUCF sector is different from the area of cultivated histosols reported under the agriculture sector. (paragraph 68 in ARR 2013)	The information was included in the NIR.	NIR Chapter 7 (7.5.1)
LULUCF/General	Include an explanation as to why the total land area has increased since 1990. (paragraph 69 in ARR2013)	Explanation as to why Japan's total land area has increased since 1990 was added to the NIR.	NIR Chapter 7 (7.1)
LULUCF/Forest land remaining forest land (5.A.1)	Include explanations for the changes in the removals trend, particularly for those that occur from one year to the next. (paragraph 70 in ARR 2013)	Explanations for the changes in the removals trend were added to the NIR.	NIR Chapter 7 (7.4), (7.4.1)
LULUCF/Forest land remaining forest land (5.A.1)	Explain the use of the "NA" notation key where it has been used for carbon stock pools in bamboo forest and the DOM and soil pools in forests with fewer standing trees. (paragraph 71 in ARR 2013)	The explanation was added to the NIR.	NIR Chapter 7 (7.4.1)
LULUCF/Forest land remaining forest land (5.A.1)	Explain the change in the trend for the carbon stock changes in DOM for this subcategory. (paragraph 72 in ARR 2013)	The change in the trend for the carbon stock changes in DOM was added to the NIR.	NIR Chapter7 (7.4.1.)
LULUCF/Forest land remaining forest land (5.A.1)	Report the area of organic soils in forest land in the annual submission to improve transparency and completeness. (paragraph 73 in ARR 2013)	The area of organic soils in forest land was added in the CRF table.	NIR Chapter 7 (7.4.1) CRF Table 5.A
LULUCF/ Land converted to forest land (5.A.2)	Explain the drivers for the decreasing trend in removals for land converted to forest land in the NIR. (paragraph 75 in ARR 2013)	The drivers for this decreasing trend in removals were added to the NIR.	NIR Chapter 7 (7.4.2.)
LULUCF/ Land converted to forest land (5.A.2)	Report disaggregated data for wetlands and settlements converted to forest land, currently reported as "IE" for the period from 1990 to 2005. (paragraph 76 in ARR 2013)	The disaggregated data were reported.	NIR Chapter 7 (7.4.2.), Table 7-18, Table 7-19, CRF Table 5.A
LULUCF/ Land converted to cropland (5.B.2)	Improve the transparency of the information on: land-use classification and representation; the different sources of information used for the estimations; and the appropriateness of the ratio used for the conversion of private forest land to other land uses that has been applied to forest land converted to cropland. (paragraph 78 in ARR 2013)	The explanation for the different sources of information used for the estimations was provide in the NIR. And the information on the appropriateness of the ratio was added to the NIR.	NIR Chapter 7 (7.5.2.)
LULUCF/ Land converted to cropland (5.B.2)	Include the explanation provided for the reversal of the decreasing trend in emissions from land converted to cropland. (paragraph 79 in ARR 2013)	The explanation was added to the NIR.	NIR Chapter 7 (7.5.2.)

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
LULUCF/ Land converted to Settlements (5.C.2)	Provide explanations for the large inter-annual changes in the area and/or net emissions.(Paragraph 80 in ARR2013)		NIR Chapter 7 (7.6.2.) CRF Table 5.C
LULUCF/ Land converted to grassland (5.C.2)	Report the subcategories of land converted to grassland separately. (paragraph 81 in ARR 2013)	For settlements converted grassland, carbon stock changes were reported.	NIR Chapter 7 (7.6.2)
LULUCF/ Land converted to settlements (5.E.2)	Provide explanations for the large inter-annual changes. (paragraph 80 in ARR 2013)	Explanations for the large inter-annual change add to the NIR.	NIR Chapter 7 (7.8.2)
LULUCF/ Other land remaining other land (5.F.1)	Report the abandoned cultivated areas under an appropriate land-use category. (paragraph 82 in ARR 2013)	Reexamination of reporting the abandoned cultivated areas has been started, but it is necessary to continue further discussion on definition of the areas and data on their converted land areas. Therefore, this issue will be dealt with in the future submission.	NIR Chapter 7 (7.5.1) (7.9.1)
LULUCF/ Direct N_2O emissions from N fertilization (5.(I))	Report N_2O emissions from N fertilization of forest land, avoiding double counting of the emissions between the LULUCF and agriculture sectors. (paragraph 83 in ARR 2013)	N_2O emissions from N fertilization of forest land were calculated.	NIR Chapter 7 (7.10.) CRF Table 5(I)
KP-LULUCF /Overview	Present more transparently disaggregated uncertainty calculations in the annual submission to enable the review of the uncertainties. (ARR2013, para 99)	More detailed information on the uncertainties that the 2013 submission was added in this NIR.	NIR Chapter 11 (11.4.1.5)
KP-LULUCF /Deforestation	Provide information on the possible over or underestimation of the rate of deforestation based on the use of satellite imagery. (ARR2013, para 101)	Information on the possible over or underestimation was added in this NIR.	NIR Chapter 11 (11.3.2.3.a)
KP-LULUCF /Deforestation	Include information to clarify that the area of deforestation is fully subtracted from the area subject to forest management, and removals are not overestimated under forest management. (ARR2013, para 102)	Information on the subtraction of areas of deforestation from those of forest management was added in this NIR.	NIR Chapter 11 (11.3.2.4.a)
KP-LULUCF /Deforestation	Review the status of the areas being reported as having lost cover but which are not yet classified as deforested. (ARR2013, para 103)	The area was reviewed, and the value reported in the previous NIR as the area was revised in this NIR.	NIR Chapter 11 (11.5.3)
KP-LULUCF /Forest Management	Include the appropriate references to the legislation that has motivated the practices or activities since 1990. (ARR2013, para 104)	Information on the legislation was added in this NIR.	NIR Chapter 11 (11.3.2.4.a.b))
KP-LULUCF /Forest Management	Include additional information on how forest management is distinguished from managed forest. (ARR2013, para 105)	Information on how forest management was distinguished from managed forest was added in this NIR.	NIR Chapter 11 (11.3.2.4.a.)

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
KP-LULUCF /Forest Management	Report the time frames for tree planting after harvest. (ARR2013, para 106)	Information on the time frames for tree planting after harvest was added in this NIR.	NIR Chapter 11 (11.5.3)
KP-LULUCF /Revegetation	Report the non-estimated carbon pools as “NE” instead of “NA” in CRF table 5(KP-I) B.4. (ARR2013, para 107)	Reporting the non-estimated carbon pools was changed from “NA” to “NE”.	KP-CRF Table “5(KP-I) B.4”
Waste/Sector Overview	Provide, in the NIR, more detailed descriptions of the subcategories and a flow chart of waste management processes for the different types of waste with their interrelations, from their generation to their final destination. (ARR2013 para 86)	More detailed descriptions of the subcategories and a flow chart of waste management processes for the different types of waste with their interrelations, from their generation to their final destination were provided in the NIR.	NIR Chapter 8 (8.1.1.)
Waste, Solid waste disposal on land (6.A.1.)	Include, in the NIR, a table with a description of the country-specific classes of MSW to explain the correspondence between the two classifications and justify the choice of the relevant IPCC default EFs. (ARR2013 para 88)	A table with a description of the country-specific classes of MSW to explain the correspondence between the two classifications and justify the choice of the relevant IPCC default EFs were included in the NIR.	NIR Chapter 8 (8.2.)
Waste/Emissions from Other Managed Landfill Sites (6.A.3)	Include a clear description of inappropriately landfilled MSW in the NIR. (ARR2013 para 88)	A clear description of inappropriately landfilled MSW was included in the NIR.	NIR Chapter 8 (8.2.4.1.)
Waste/Emissions from Other Managed Landfill Sites (6.A.3)	Use appropriate notation key “NA” instead of “NE” for CO_2 emissions from unmanaged landfills. (ARR2013 para 89)	Because the condition of CO_2 emissions from the fire from inappropriate disposal is unidentified, and actual data are unavailable, notation key “NE” is appropriate for the circumstances and will be used for CO_2 emissions from inappropriate disposal.	NIR Chapter 8 (8.2.4.1.) CRF Table 6.A.
Waste/Wastewater Handling (6.B.)	Enhance the QC procedures regarding the consistency between the NIR and the CRF tables and the use of the notation keys. (ARR2013 para 91)	Descriptions of the CRF Table were revised.	CRF Table 6.B(Sheet2)
Waste/Domestic and Commercial Wastewater (6.B.2-)	Enhance the transparency of the description of the country-specific method with respect to CH_4 recovery from domestic and commercial wastewater. (ARR2013 para 92)	A clear description of the country-specific method with respect to CH_4 recovery from domestic and commercial wastewater was provided in the NIR.	NIR Chapter 8 (8.3.2.5.)
Waste/Industrial Wastewater (6.B.1.)	Access data on CH_4 recovery for industrial wastewater. (ARR2013 para 92)	No statistics on CH_4 recovery for industrial wastewater is available, it will be considered as a long-term issue.	-
Waste/Waste Incineration (6.C.)	Provide more detailed descriptions of the recalculations. (ARR2013 para 94)	More detailed descriptions of the recalculations were provided in the NIR.	NIR Chapter 8 (8.1.3.) and Source-specific Recalculations

Sector/Category	Recommendations by ERT	Actions taken	NIR/CRF
Cross-cutting/Inventory planning	Move all information in annex 6.1 to the NIR to chapter 1 and also include additional information as contained in the presentation on the national system provided to the ERT during the review. (ARR2013 para 11)	More organized information on Japan's national system will be provided in the NIR in its annual submission for 2015 taking into account the revised outline and general structure of national inventory report under the Revision of UNFCCC reporting guidelines on annual inventories.	-
Cross-cutting/Inventory preparation	Strengthen QC procedures in order to avoid inconsistencies between the NIR and the CRF tables (see paras. 23, 24, 86 and 91). (ARR2013 para 13)	Actions taken in response to the recommendations were provided in the NIR.	NIR Chapter 10 (10.4.1.3.) Table 10-12 See the comments for ARR2013, para 23, 24, 86, 91)
Cross-cutting/Inventory preparation	Improve the text descriptions in the NIR to ensure that the recalculations for all categories are transparently described. (ARR2013 para 17)	The text description of the recalculation for all categories were provided in the NIR.	NIR Chapter 3-8 "Source-specific Recalculations" and Chapter 10
Cross-cutting/Inventory preparation	Consider ways to address the implementation of the ERT's recommendations in a timely manner. (ARR2013 para 18)	The Committee for Greenhouse Gas Estimation Methods (see "Committee for Greenhouse Gas Estimation Methods Annex" (A6.1.3.5)) address all the recommendations raised by ERT, and tireless efforts has been made to tackle the issues and improve a national GHG inventory with due consideration of the priority; Current status of all the UNFCCC-ERT recommendations were provided in the NIR.	NIR Chapter 10 (10.4.1.3.) Table 10-12

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

Japan reports supplementary information on afforestation/reforestation (AR), deforestation (D), forest management (FM) and revegetation (RV) as LULUCF activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol. 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 FY2012 by those activities were 52,842 Gg-CO_2 eq. (Table 11-2).

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[(1)]					Greenhouse gas sources reported[(2)]						
		Above-ground biomass	Below-ground biomass	Litter	Dead wood	Soil	Fertilization[(3)]	Drainage of soils under forest management	Disturbance associated with land-use conversion to croplands	Liming	Biomass burning[(4)]		
							N_2O	N_2O	N_2O	CO_2	CO_2	CH_4	N_2O
Article 3.3 activities	Afforestation and Reforestation	R	R	R	R	R	NO			NO	IE	R	R
	Deforestation	R	R	R	R	R			R	R	NO	NO	NO
Article 3.4 activities	Forest Management	R	R	R	R	R	R	NO		NO	IE	R	R
	Cropland Management	NA	NA	NA	NA	NA			NA	NA	NA	NA	NA
	Grazing Land Management	NA	NA	NA	NA	NA				NA	NA	NA	NA
	Revegetation	R	R	R	IE	R				R	NO	NO	NO

*R: Reported. 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	Base year	Net emissions/removals						Accounting parameters	Accounting quantity
		2008	2009	2010	2011	2012	Total		
	(Gg CO_2 equivalent)								
A. Article 3.3 activities									
A.1. Afforestation and Reforestation									-2,320.58
A.1.1. Units of land not harvested since the beginning of the commitment period		-426.28	-447.99	-469.67	-482.25	-494.39	-2,320.58		-2,320.58
A.1.2. Units of land harvested since the beginning of the commitment period									
A.2. Deforestation		2,167.75	2,646.75	3,036.04	1,632.98	1,954.89	11,438.42		11,438.42
B. Article 3.4 activities									
B.1. Forest management (if elected)		-46,363.73	-48,096.39	-50,931.50	-51,638.70	-53,140.34	-250,170.66		-247,451.17
3.3 offset								9,117.84	-9,117.84
FM cap								238,333.33	-238,333.33
B.2. Cropland management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.3. Grazing land management (if elected)	NA	NA	NA	NA	NA	NA	NA	NA	NA
B.4. Revegetation (if elected)	-77.82	-1,079.70	-1,110.88	-1,128.66	-1,142.08	-1,161.85	-5,623.17	-389.12	-5,234.05

※ Japan's actual net removals by FM after application of 3.3 offset for the first commitment period of the Kyoto Protocol exceeded the upper limit given to Japan in the appendix to decision 16/CMP.1, which was 13 Mt-C times 5 (238,333 Gg-CO_2). Therefore, Japan accounted for the removals by the upper limit..

※ Since the total anthropogenic GHG emissions by sources and removals by sinks in managed forests since 1990 are larger than the net source of emissions incurred under Article 3.3, the offset rule according to paragraph 10 of the annex to decision 16/CMP.1 is applied to Japan.

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

11.2. General information

11.2.1. Definition of forest and any other criteria

Japan's definitions of forest are identified as the following, in accordance with decision 16/CMP.1 and the requirement from *GPG-LULUCF*.

- 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 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 11-3).

Table 11-3 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 sasa).

※ See section 7.2.2. 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 11-4 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.

11.2.2. Elected activities under Article 3, paragraph 4 of the Kyoto Protocol

Japan elected FM and RV defined by decision 16/CMP.1 in paragraph 6 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.

11.2.2.1. Forest Management

FM is defined by decision 16/CMP.1 in paragraph 1 (f) of the annex 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 by recalling *GPG-LULUCF* which the party is requested to use in accordance with decision 16/CMP.1, paragraph 2.

- 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.

11.2.2.2. Revegetation

RV is defined by decision 16/CMP.1, annex, paragraph 1 (e), 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 the following by recalling *GPG-LULUCF*.

- 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[2]. Activities which cover less than an area of 0.05 ha or meet the definitions of AR are not included.

[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] 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".

11.2.3. 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 11.2.1 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 and RV explained in section 11.2.2 above have been implemented and applied consistently over time.

11.2.4. 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 RV activities only in settlements. Therefore, there is no overlapping between FM and RV.

11.3. Land-related information

11.3.1. 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 11.2.1, Japan determines the spatial assessment unit used for determining the area of the units of land under Article 3.3 as 0.3 ha.

11.3.2. Methodology used to develop the land transition matrix

11.3.2.1. Description of land transition matrix (CRF-NIR Table 2)

Table 11-5 shows the land transition matrix related to the activities under Articles 3.3 and 3.4. The FM area in Japan is estimated by using the narrow approach concept described in section 4.2.7.1, Chapter 4 of the *GPG-LULUCF*. 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 11-5. 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 11-5.

Table 11-5 Land transition matrix of Kyoto Protocol activities (CRF-Table NIR 2)

FROM 2011 \ TO 2012		Article 3.3 activities		Article 3.4 activities				Other	Total
		Afforestation and reforestation	Deforestation	Forest Management (if elected)	Cropland Management (if elected)	Grazing Land Management (if elected)	Revegetation (if elected)		
		(kha)							
Article 3.3 activities	Afforestation and Reforestation	32.23	0.00						32.23
	Deforestation		341.00						341.00
Article 3.4 activities	Forest Management (if elected)		3.39	15,141.91					15,145.30
	Cropland Management[4] (if elected)	-	-		-	-	-		0.00
	Grazing Land Management[4] (if elected)	-	-		-	-	-		0.00
	Revegetation[4] (if elected)	0.00			-	-	78.51		78.51
Other		0.10	2.13	178.97	-	-	1.55	22,019.59	22,202.34
Total area		32.33	346.51	15,320.88	0.00	0.00	80.06	22,019.59	37,799.38

11.3.2.2. 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.

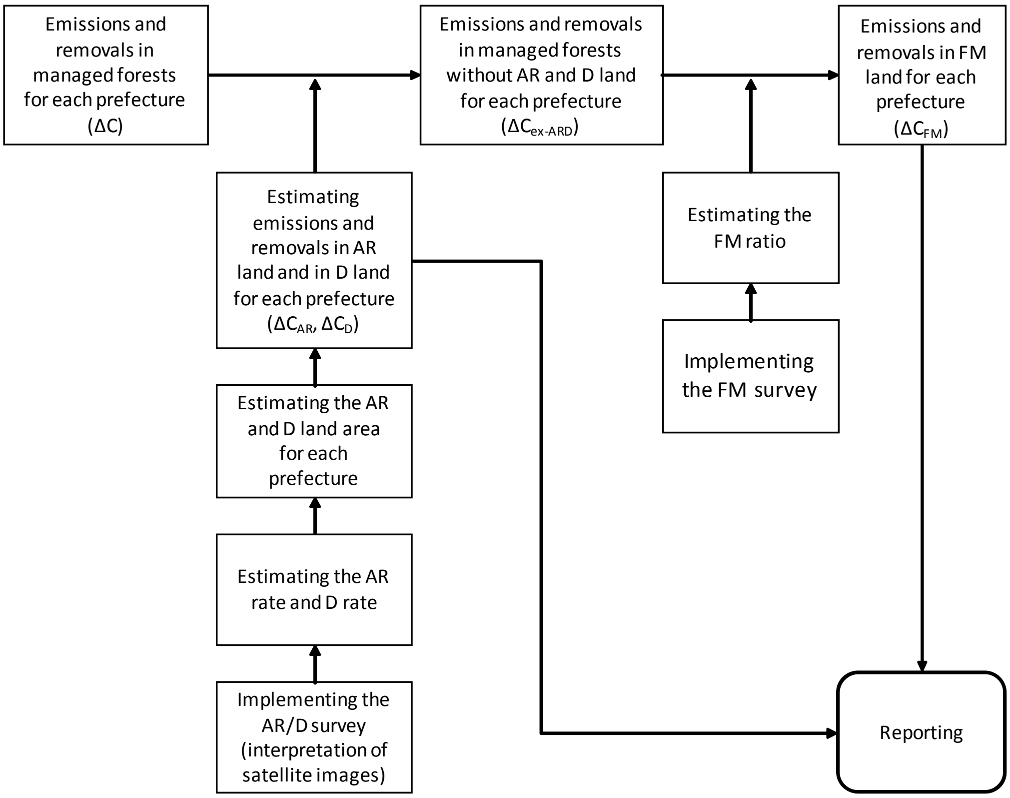

Figure 11-1 Procedures to estimate emissions and removals for AR, D and FM activities

11.3.2.3. Afforestation/Reforestation and Deforestation

11.3.2.3.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 2009 and 2011, while images of upper half were taken and in 2010 and 2012. The interpretation through comparison of 2-year (2009 and 2011) satellites images are implemented in order to account for the carbon stock change in 2011. 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-FY2012 is estimated as follows: The increase in AR rate in each year

during FY1990-FY2012 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 FY2012 is estimated by dividing the increase of AR plots in FY2012, 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-FY2012 is estimated as follows: The increase in D rate in each year during FY1990-FY2012 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 FY2012 is estimated by dividing the increase of D plots in FY2012, 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-FY2012 is calculated by multiplying the land area for each prefecture by the AR rate during FY1990-FY2012, which is obtained by summating the increase of AR rate in each year during FY1990-FY2012. In the same way, the D land area for each prefecture during FY1990-FY2012 is calculated by multiplying the land area for each prefecture by the D rate during FY1990-FY2012, which is obtained by summating the increase of D rate in each year during FY1990-FY2012.

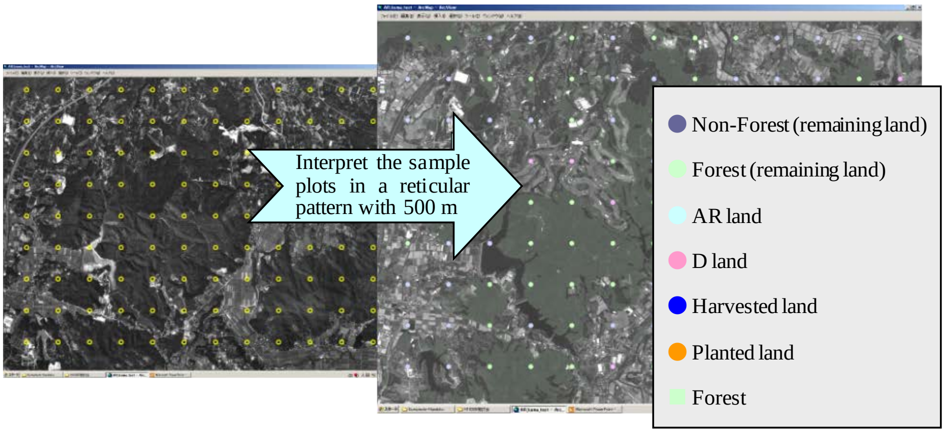

Figure 11-2 ARD land identification by interpreting remote sensing images

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.

11.3.2.3.b. Data

Japan determines the ARD land area by using the following data.

Table 11-6 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 – 2012)	2.5	Raster

11.3.2.3.c. Land-use change in deforested land

Japan determines the area of D land in accordance with the procedures mentioned in section 11.3.2.3.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 11.3.2.3.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.

11.3.2.4. Forest Management

11.3.2.4.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 11.2.2.1., 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 11-7 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	0.85	0.88
		Minami-kanto, Tokai	0.68	0.83
		Kinki, Chugoku, Shikoku, Kyusyu	0.69	0.86
	Hinoki cypress	Tohoku, Kanto, Chubu	0.82	0.89
		Kinki, Chugoku, Shikoku, Kyusyu	0.79	0.90
	Japanese larch	All	0.84	0.76
	Other	All	0.65	0.79
Semi-natural forest / All		All	0.32	0.65

* Data at the end of FY2012. 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 11-8 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 11-8 Area of protected/conserved tennensei-rin forests

[Unit: kha]

Protected / Conserved forest type	Private forest	National forest	Total
Protection Forest	2,768	4,522	7,290
Area for Conservation facility installation project	1	0	1
Protected Forest	0	806	806
Special Protected Zones in National Parks	41	108	149
Class I Special Zones in National Parks	36	146	182
Class II Special Zones in National Parks	121	202	323
Special Protected Zones in Quasi-National Parks	9	38	47
Class I Special Zones in Quasi-National Parks	31	104	136
Class II Special Zones in Quasi-National Parks	98	84	182
Special Zone in National Environment Conservation Area	0	9	9
Special Seed Forest	1	1	1
Total	3,106 (2,663)	6,019 (4,282)	9,126 (6,945)

* NFRDB (1 April 2013)
* This table includes forests with less standing trees.
* ( ) means total land area excluding overlaps.

11.3.2.4.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 7.4.1.b).1, Chapter 7 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.

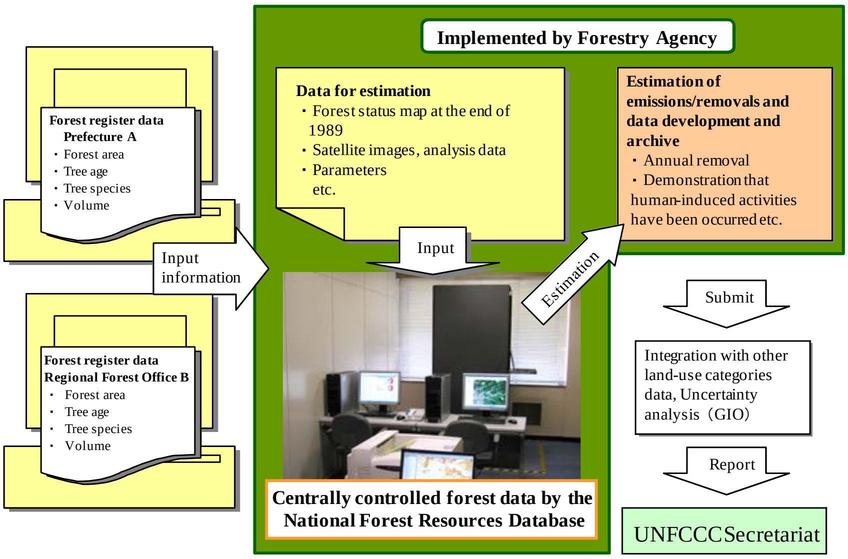

Figure 11-3 Summary of the National Forest Resources Database

11.3.2.5. Revegetation

11.3.2.5.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[3].

[3] Land-use change from the previous year to each corresponding year is applied when the area ratio of "single year" is used.

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 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 11-9 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.

11.3.2.5.b. Data

The data applied in estimating RV land area are shown below.

Table 11-10 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)
Green area on roads	・Number of tall trees	・Road Tree Planting Status Survey (FY1987, 1992, 1997, 2002, 2007, 2008, 2009, 2010, 2011, 2012, 2013)
	・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
Green areas around sewage treatment facilities	・Green area	・Sewage Treatment Facility Status Survey (FY2008, 2009, 2010, 2011, 2012)
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)
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)
Green areas around government buildings	・Total land area and building area	・Complete census for FY2008, 2009, 2010, 2011, 2012
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)

11.3.3. Maps and/or database to identify the geographical locations, and the system of identification codes for the geographical locations

Section 4.2.2.2 of the *GPG-LULUCF* 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 4.2.4 in Chapter 4 of the *GPG-LULUCF*, 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. Each activity under Articles 3.3 and 3.4 is detected as described in sections 11.3.2.3-11.3.2.5, 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 elected activities under Article 3.4, under the provisions of paragraph 8 of the annex to the decision 16/CMP.1, and lands subject to elected activities under Article 3.4.

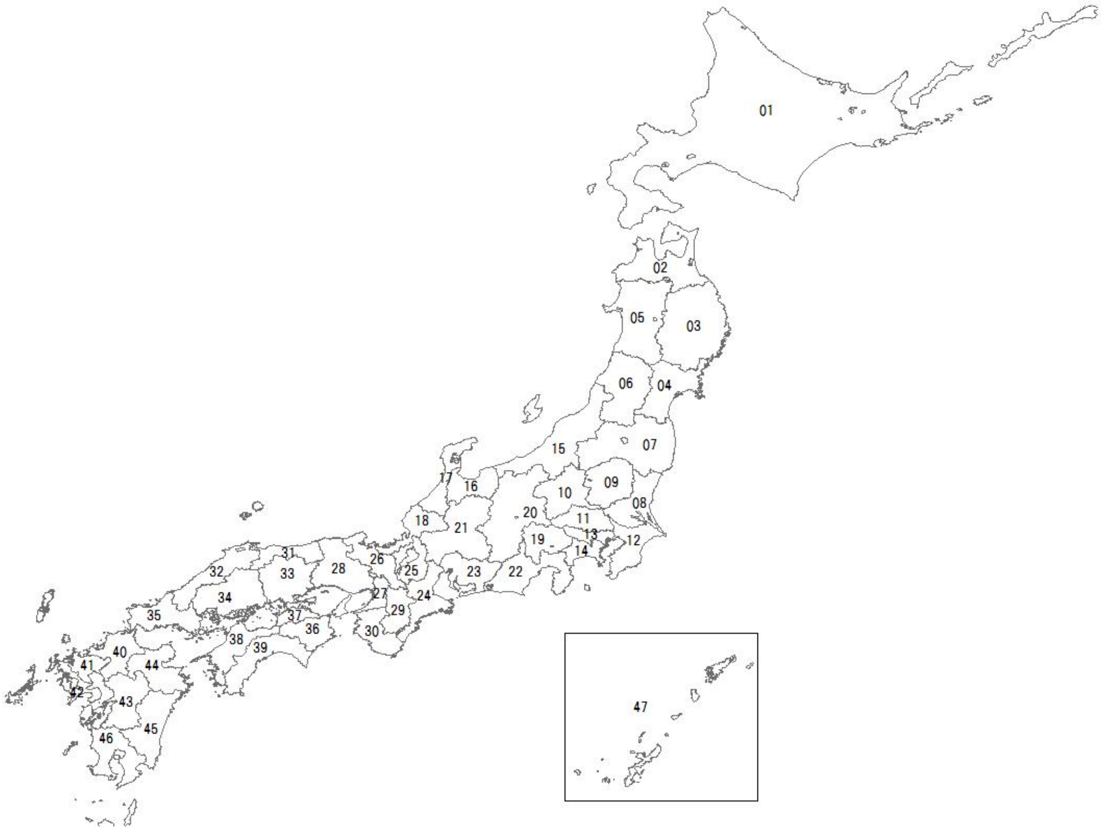

Figure 11-4 Japan's determination of identification codes

Table 11-11 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		

11.4. Activity-specific information

11.4.1. Methods for carbon stock change and GHG emission and removal estimates

11.4.1.1. Description of the methodologies and the underlying assumptions used

11.4.1.1.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 change method in accordance with the *GPG-LULUCF*. 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]

<u>Carbon stock change due to biomass growth, felling, fuelwood gathering and disturbance after land conversion</u>

$$\Delta C_{SC} = \sum_k \left\{ (C_{t2} - C_{t1}) / (t_2 - t_1) \right\}_k$$

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.

$$C = \sum_j \{[V_j \times D_j \times BEF_j] \times (1 + R_j) \times CF\}$$

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 (= 0.5[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 *GPG-LULUCF*.

$$\Delta C_L = \sum_i \{A_i \times (B_a - B_{b,i}) \times CF\}$$

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 7.4.1, Chapter 7 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 7-6a, Chapter 7 of this report.

- ***Activity data***

The activity data is AR land area which was calculated by using the procedure described in section 11.3.2.3 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 change method provided by the *GPG-LULUCF* 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.

$$\Delta C_{DW} = \sum_i \{A_i \times (C_{DW20} - C_{DW,i}) / 20\}$$

$$\Delta C_{LT} = \sum_i \{A_i \times (C_{LT20} - C_{LT,i}) / 20\}$$

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 *GPG-LULUCF* 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 7.4.1.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”.

$$\Delta C_{Soil} = \sum_i \left\{ A_i \times (C_{Soil20} - C_{Soil,i}) / 20 \right\}$$

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 11.3.2.3 of this report.

c) Other gases

1) Direct 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, direct N_2O emissions from N fertilization are reported in FM in a lump. Therefore, this category in AR has been reported as “IE”.

2) CO_2 emissions from agricultural lime application

According to a survey in 2009 for private forests, all prefectures answered that no lime was applied to forest management practices like regeneration and tending in private forests. In addition, according to a survey conducted on national forests in 2013, no lime had been applied to such forest management practices in national forests, either. Therefore, lime application in forest land is considered as “not occurred” in Japan. Hence, this category has been reported as “NO” from 2008 to present.

3) Biomass burning

GHG emissions from wild fire exist in Japan as explained in section 7.14.a), Chapter 7 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.

d）　Results

Table 11-12　Net emissions and removals from AR activity

	2008	2009	2010	2011	2012
	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］
AR	-426.28	-447.99	-469.67	-482.25	-494.39
Above-ground biomass	-242.82	-256.83	-267.70	-275.85	-284.23
Below-ground biomass	-65.13	-68.09	-71.12	-72.02	-73.83
Dead wood	-71.45	-74.30	-83.28	-89.11	-93.48
Litter	-30.95	-32.19	-33.38	-33.03	-32.05
Soils	-15.96	-16.60	-14.21	-12.24	-10.81
Other gases	0.030	0.012	0.006	0.008	0.002

* CO_2) +: Emissions, -: Removals

11.4.1.1.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 *GPG-LULUCF*.

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 7-6b in Chapter 7 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 11.3.2.3.c.

$$\Delta C_{D-LB} = \Delta C_{DG-LB} + \Delta C_{DS-LB}$$
$$\Delta C_{DG-LB} = A_{5,DG} \times C_{G-LB}$$
$$\Delta C_{DS-LB} = \Delta C_{RV-LB} \times RA_{DS-RV}$$

ΔC_{D-LB} : Annual carbon stock change due to living biomass growth after D activity [t-C/yr]
ΔC_{DG-LB} : Carbon stock change due to living biomass growth in grassland subject to D activity [t-C/yr]
ΔC_{DS-LB} : Carbon stock change due to living biomass growth in settlements subject to D activity [t-C/yr]
ΔC_{RV-LB} : Carbon stock change in living biomass due to all RV practices [t-C/yr] (see section 11.4.1.1.d)
$A_{5,DG}$: Area of grassland subject to D activity within the past 5 years [ha]
C_{G-LB} : Carbon stock change per area in grassland [t-C/ha/yr]
RA_{DS-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 7-6b in Chapter 7 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 11.3.2.3. The D land area where RV practices have been taken place is calculated by the method described in section 11.4.1.1.d.

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 *GPG-LULUCF*. 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 7-7, 7-8 and 7-9 in Chapter 7 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） Other gases

1） N_2O emissions from disturbance associated with land-use conversion to cropland

The *GPG-LULUCF* Tier 1 method, which utilizes mineralized soil carbon stocks due to disturbances associated with land-use conversion to cropland as an activity data, is applied to estimate N_2O emissions. The same methodology and parameters that were explained in section 7.12 b), Chapter 7 of this report are used. The carbon loss due to mineralization as a result of conversion to cropland in D area is calculated by all carbon loss due to deforestation multiplied by the ratio of land-use change to cropland in D area.

2） CO_2 emissions from agricultural lime application

CO_2 emissions from lime application in D land are estimated by the total CO_2 emissions from lime application in cropland in accordance with the *GPG-LULUCF* Tier 1 method (NIR Chapter 7 Section 7.13 b)) multiplied by the ratio of D area to the total area of cropland. Japan did not elect cropland management (CM) under Article 3.4 of the Kyoto Protocol; therefore CO_2 emissions from agricultural lime application to be reported under the Kyoto Protocol are only those in “cropland converted from forest land” since 1990 (identified as D land). However, it is difficult to directly determine the amount of lime and dolomite applied in such lands. Therefore it is assumed that lime application is conducted uniformly in all cropland.

3） 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 NOx emissions are reported as “NO”.

d）Results

Table 11-13 Net emissions and removals from D activity

		2008	2009	2010	2011	2012
		[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]
D		2,167.75	2,646.75	3,036.04	1,632.98	1,954.89
	Above-ground biomass	1,093.05	1,240.86	1,466.44	738.99	979.75
	Below-ground biomass	279.44	316.22	376.34	188.02	250.26
	Dead wood	365.56	568.50	662.98	331.50	358.05
	Litter	145.64	232.44	265.45	133.01	144.09
	Soils	279.08	283.70	260.21	236.94	218.43
	Other gases	4.97	5.03	4.62	4.53	4.31

* CO_2) +: Emissions, -: Removals

11.4.1.1.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 change 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[4,5]. For tennensei-rin forest, the area 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]

[4] 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.

[5] 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.

k : Type of forest management
m : Age class or forest age
j : Tree species

Based on expert judgment, CO_2 emissions from organic soil are extremely low, because soil drainage activities for organic soil in forest land are very rarely conducted 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 University) to accommodate for Japanese climate, soil, and vegetation conditions. Detailed explanation of the CENTURY-jfos model is provided in section 7.4.1.b) 2), Chapter 7 of this report.

c） Other gases

1） Direct N_2O emissions from N fertilization

N_2O emissions from N fertilization exist in Japan as explained in section 7.10.a), Chapter 7, 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, direct 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 7.10.b), Chapter 7, of this report.

2） N_2O emissions from drainage of soils

Based on expert judgment that a soil drainage activity for organic soils in forest land does not occur in Japan, this category is reported as "NO".

3） CO_2 emissions from agricultural lime application

According to a survey in 2009 for private forests, all prefectures answered that no lime was applied to forest management practices like regeneration and tending in private forests. In addition, a survey conducted on national forests in 2013, no lime had been applied to such forest management practices in national forests, either. Therefore, lime application in forest land is considered as "not occurred" in Japan. Hence, this category has been reported as "NO" from 2008 to present.

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.

d） Results

Table 11-14 Net emissions and removals from FM activity

	2008	2009	2010	2011	2012
	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］	［Gg-CO_2］
FM	-46,363.73	-48,096.39	-50,931.50	-51,638.70	-53,140.34
Above-ground biomass	-35,506.61	-37,313.20	-40,055.74	-40,972.26	-42,382.77
Below-ground biomass	-8,973.80	-9,413.71	-10,049.53	-10,349.10	-10,763.88
Dead wood	116.33	619.68	1,116.49	1,559.44	1,806.54
Litter	-472.98	-421.28	-351.20	-293.15	-261.58
Soils	-1,541.31	-1,574.18	-1,594.99	-1,588.02	-1,540.35
Other gases	14.64	6.30	3.47	4.38	1.70

* CO_2) +: Emissions, -: Removals

11.4.1.1.d. 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)[6]”.

- ***Methodology***

$$\Delta C_{RVLB} = \sum_i \left(\Delta C_{LBG,i} - \Delta C_{LBL,i} \right)$$

$$\Delta C_{LBG,i} = \Delta B_{LBG,i}$$

$$\Delta B_{LBG,i} = \sum_j \left(NT_{i,j} \times C_{Ratei,j} \right)$$

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[7]***

➢ ***Urban parks***

Carbon stock changes due to the loss of living biomass in urban parks are assumed to be zero based on Tier 1 method in *GPG-LULUCF* (p. 3.297), because the average age of trees is found to be less than or equal to 20 years in the tree survey for sample urban parks[8].

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 *GPG-LULUCF* (p. 3.297, Table 3A.4.1) 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

[6] “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.

[7] The Tier 1b method described in the GPG-LULUCF and the Tier 2 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.

[8] 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.

taking into account the distribution ratio of tree species in sample urban parks[9]. 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 20 years for those trees planted in randomly extracted green areas on roads.

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[10].

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.

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9 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.

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.

- ***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%.[11]

Table 11-15 Area of urban parks which were not classified as forest land on 31 December 1989

At the end of FY2012

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2012	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	5.96%	3,330.52	No
	Non-forest	94.04%	52,577.84	Yes
	Total	100.00%	55,908.36	-

Table 11-16 Area of urban parks (remaining land / converted land)

At the end of FY2012

	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)	0.21%	110.72	25,979
	Remaining	99.79%	52,467.12	12,311,014
	Total	100.00%	52,577.84	12,336,993

➢ ***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

[11] 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.

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 11-17 Area of green areas on roads which have been classified as RV

At the end of FY2012

	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 2013	FY1990 - FY2012				
	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	6,988,022	2,645,952	99.00%	5.96%	15,364	2,463,363
Expressway (managed by now-defunct public corporation)	0.000829903	1,096,380	8,261,795	7,165,415	100.00%	5.96%	5,592	6,738,563
Total	–	5,438,450	15,249,817	9,811,367	–	–	20,956	9,201,927

Table 11-18 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 FY2012

		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	0.21%	19,377	44.13
		Remaining	99.79%	9,182,549	20,912.22
		Total	100.00%	9,201,927	20,956.35
	General roads	Converted	0.21%	5,187	32.35
		Remaining	99.79%	2,458,176	15,331.64
		Total	100.00%	2,463,363	15,364.00
	Expressway	Converted	0.21%	14,190	11.78
		Remaining	99.79%	6,724,373	5,580.58
		Total	100.00%	6,738,563	5,592.35

➢ *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 11-19 Area of green areas at ports and activity data (remaining land / converted land)

At the end of FY2012

Land-use category	Area ratio of land which has been converted in the current year	Area [ha]	Activity data [Number of tall trees]
Converted	0.21%	3.56	811
Remaining	99.79%	1,688.79	384,388
Total	100.00%	1,692.35	385,199

➢ *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).[12] All green areas around sewage treatment facilities are located in "settlements".

Table 11-20 Area of green areas around sewage treatment facilities which were not classified as "Forest land" on 31 December 1989

At the end of FY2012

Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2012	Area (ha) (Green areas)	Classified as RV land
Forest	5.96%	41.11	No
Non-forest	94.04%	649.06	Yes
Total	100.00%	690.17	-

Table 11-21 Area and activity data of "Green areas around sewage treatment facilities" [number of tall trees] (remaining land / converted land)

At the end of FY2012

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)	0.21%	1.37	554
Remaining	99.79%	647.69	262,405
Total	100.00%	649.06	262,959

➢ *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.

12 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 11-22 Activity data and area of “Green areas by greenery promoting systems for private green space”

Certification year	Location	Area [m²]	Breakdown of area [m²]			Area	Activity data
			Ground	Roof	Wall	Wall green area by greenery promoting system for private green space [m²]	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		4,021	147
2002	Minato-ku, Tokyo	52,766	10,679			10,679	672
2002	Minato-ku, Tokyo	84,780	8,846	9,386		18,232	813
2003	Minato-ku, Tokyo	5,519	1,374			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			1,271	90
2006	Hiroshima City	4,453	130	783		913	1
2007	Hiroshima City	14,353	4,058			4,058	261
2007	Fukuoka City	5,689	773	799		1,572	19
2008	Ishikawa Prefecture	7,281	682	1,411		2,093	19
2009	Setagaya-ku, Tokyo	5,526	1,116			1,116	51
2009	Setagaya-ku, Tokyo	6,459	1,370			1,370	15
2010	–						
2011		0	0	0	0	0	0
2012		0	0	0	0	0	0
Total		251,912	37,011	18,485	234	55,776	3,243

* There were no areas certified in FY2010, FY2011 and FY2012.

➢ ***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).[13]

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 11-23 Activity data and area of ”Green areas along rivers and erosion control sites” (remaining land / converted land)

At the end of FY2012

	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 m² or more (classified as RV land)	Converted (except land converted from forest land)	0.21%	3.50	1,955
	Remaining	99.79%	1,657.39	926,420
	Total	100.00%	1,660.89	928,375

➢ ***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).[14]

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[13] 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.

[14] For green areas around government buildings, the number of tall trees per area was estimated by dividing the number of 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.

Table 11-24 Area of "Green areas around government buildings" which were not classified as "Forest land" on 31 December 1989

At the end of FY2012

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2012	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	5.96%	18.59	No
	Non-forest	94.04%	293.48	Yes
	Total	100.00%	312.07	-

Table 11-25 Area and activity data of "Green areas around government buildings" (remaining land / converted land)

At the end of FY2012

	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)	0.21%	0.62	67
	Remaining	99.79%	292.86	31,863
	Total	100.00%	293.48	31,930

➢ *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).[15]

Table 11-26 Area of "Green areas around public rental housing" which were not classified as "Forest land" on 31 December 1989

At the end of FY2012

	Land-use category	Area ratio of land which has been converted from forest land to settlements from FY1990 to FY2012	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	5.96%	141.05	No
	Non-forest	94.04%	2,226.79	Yes
	Total	100.00%	2,367.84	-

Table 11-27 Area and activity data of "Green areas around public rental housing" (remaining land / converted land)

At the end of FY2012

	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)	0.21%	4.69	1,031
	Remaining	99.79%	2,222.10	488,639
	Total	100.00%	2,226.79	489,670

15 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.

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[16], 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 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

[16] 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 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.

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[17] [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)

- ***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[18] conducted in urban parks which have been established within 20 years (1.20 t-C/ha/yr) (Tonosaki et al., 2013)[19].

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[17] Soil organic carbon pools are the subject of estimation of carbon stock changes in soils in RV land.

[18] Soil carbon stocks (at 30 cm depth) were measured for areas with different types of vegetation cover in urban parks (planted: 21 areas, lawn: 19 areas, bare: 21 areas), which are located in Tokyo and were established in different years.

[19] 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

This value is applicable to land, which is the subject of revegetation activity and was established within 20 years, because the value is based on the results of surveys conducted in urban parks which have been established within 20 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 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） Carbon emissions from lime application

Japan estimates carbon emissions from lime application in all urban green facilities. For urban parks and green areas on roads (lime application is implemented only in green areas on general roads), the amount of lime applied per area is estimated. For other urban green facilities, the amount of lime applied per area of urban parks is applied.

Carbon emissions are estimated for all RV land together because the estimation method is similar regardless of remaining or converted land.

- ***Methodology***

$$C_{RVLm} = C_{RVCaCO_3} + C_{RVCaMg(CO_3)_2}$$
$$C_{RVCaCO_3} = \sum_i \left(A_i \times \Delta C_{RVCaCO_3,i} \right) \times EF_{Limestone}$$
$$C_{RVMg(CO_3)_2} = \sum_i \left(A_i \times \Delta C_{RVMg(CO_3)_2,i} \right) \times EF_{Dolomite}$$

C_{RVLm} : Annual carbon emissions in RV lands due to lime application [t-C/yr]
$C_{RVCaCO3}$: Carbon emissions in RV lands due to calcic limestone application [t-C/yr]
$C_{RVCaMg(CO3)2}$: Carbon emissions in RV lands due to dolomite application [t-C/yr]
A_i : Area of RV land (total of remaining and converted lands of urban green facilities, *i*) [ha]
$\Delta C_{RViCaCO3,\,i}$: Amount of calcic limestone application per area of RV land (urban green facilities, *i*) [t-C/ha]

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.

$\Delta C_{RViCaMg(CO3)2, i}$: Amount of dolomite application per area of RV land (urban green facilities *i*) [t-C/ha]
$EF_{Limestone}$: Emission factor for calcic limestone [t-C/t]
$EF_{Dolomite}$: Emission factor for dolomite [[t-C/t]
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 public rental housing and Green areas around government buildings)

- ***Parameters***

➢ ***Urban parks***

The amount of calcic limestone application per area is established as 298.4 g/ha/yr based on the results of a questionnaire survey carried out for 11,274 urban parks. The amount of dolomite application per area is established as 1,088.4 g/ha/yr based on the results of a questionnaire survey carried out for 9,346 urban parks.

The applied emission factors for calcic limestone and dolomite are 0.12 and 0.13, respectively (default values of *IPCC 2006 Guidelines*).

➢ ***Green areas on roads***

The amount of calcic limestone application per tall tree is established as 0.3311 g/tree/yr and the amount of dolomite application per tall tree is established as 1.5431 g/tree/yr based on the results of a questionnaire survey implemented for 40 road managers.

The applied emission factors for calcic limestone and dolomite are 0.12 and 0.13, respectively (default values of *IPCC 2006 Guidelines*).

➢ ***Urban green facilities other than Urban parks and Green areas on roads***

The parameter values for urban parks are applied because lime application in these green facilities is implemented in the same manner as in urban parks (application pattern and frequency).

- ***Activity data***

The area of all RV lands (regardless of remaining or converted land) is used as activity data.

3） 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 11-28 Area of "Urban parks" and activity data (remaining land / converted land)

At the end of FY2012

	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	99.79%	52,467.12	12,311,014
	Cropland	0.18%	94.98	22,287
	Grassland	0.03%	15.74	3,693
	Wetlands	IE	IE	IE
	Other land	IE	IE	IE
	Total	100.00%	52,577.84	12,336,994

➢ ***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 11-29 Area of "Green areas on roads" and activity data for each land-use category

At the end of FY2012

	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	99.79%	20,912.22	9,182,549
	Cropland	0.18%	37.86	16,623
	Grassland	0.03%	6.27	2,754
	Wetlands	IE	IE	IE
	Other land	IE	IE	IE
	Total	100.00%	20,956.35	9,201,927

➢ ***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 11-30 Area of "Green areas at ports" and activity data for each land-use category

At the end of FY2012

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	99.79%	1,688.79	384,388
Cropland	0.18%	3.06	696
Grassland	0.03%	0.51	115
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	1,692.35	385,199

➢ ***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 11-31 Area of "green areas around sewage treatment facilities" and activity data for each land-use category

At the end of FY2012

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	99.79%	647.69	262,405
Cropland	0.18%	1.17	475
Grassland	0.03%	0.19	79
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	649.06	262,959

➢ ***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 11-32 Area of "green areas along rivers and erosion control sites" and activity data for each land-use category

At the end of FY2012

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	99.79%	1,657.39	926,420
Cropland	0.18%	3.00	1,677
Grassland	0.03%	0.50	278
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	1,660.89	928,375

➢ ***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 11-33 Area of "green areas around government buildings" and activity data for each land-use category

At the end of FY2012

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	99.79%	292.86	31,863
Cropland	0.18%	0.53	58
Grassland	0.03%	0.09	10
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	293.48	31,931

➢ ***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 11-34 Area of "green areas around public rental housing" and activity data for each land-use category

At the end of FY2012

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	99.79%	2,222.10	488,639
Cropland	0.18%	4.02	885
Grassland	0.03%	0.67	147
Wetlands	IE	IE	IE
Other land	IE	IE	IE
Total	100.00%	2,226.79	489,671

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

1） Direct 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） Carbon emissions from lime application

Carbon emissions from lime application are estimated based on methodologies described in "remaining land: other gases" for all RV land together because the estimation method is similar regardless of remaining or converted land.

3） Biomass burning

As in the case of "remaining RV land", biomass burning activities which release carbon do not occur.

Therefore, this category has been reported as “NO”.

k） Results

Table 11-35 Emissions and removals from RV activity

		1990	2008	2009	2010	2011	2012
		[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]	[Gg-CO_2]
RV		-77.82	-1,079.70	-1,110.88	-1,128.66	-1,142.08	-1,161.85
	Above-ground biomass	-47.32	-674.80	-694.18	-703.74	-711.39	-722.72
	Below-ground biomass	-12.30	-175.45	-180.49	-182.97	-184.96	-187.91
	Dead wood	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO	IE,NO
	Litter	-0.92	-11.39	-11.73	-12.02	-12.20	-12.47
	Soils	-17.28	-218.09	-224.51	-229.97	-233.57	-238.79
	Other gases	0.003	0.037	0.038	0.039	0.040	0.041

* CO_2) +: Emissions, -: Removals

11.4.1.2. 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 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.

11.4.1.3. 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 7 in the annex to decision 15/CMP.1 in estimating emissions/removals from activities under Articles 3.3 and 3.4.

11.4.1.4. Changes in data and methods since the previous submission (recalculations)

■ ***Revisions of AR and D areas and recalculation of FM areas***

The AR and D areas are estimated by multiplying the ARD ratio, which were detected through imagery interpretation using aerial photos and satellite images, by the national land area. Some misinterpretation cases, such as misclassification of a temporary loss of biomass stock in forest land subject to the FM activity into D, have not been able to be completely excluded. In this submission, Japan reexamined the past interpretation results by applying improvement measures, such as referring to other geographical information data, and made an effort to reduce the misinterpretation on D areas.. In addition, linear development of forest such as forest road had been interpreted as D so far. However, GPG-LULUCF (p.4.27) said that "linear deforestation events" narrower than the selected minimum forest width criteria of forest definition could be accounted for as carbon stock change by FM activity, not by D activity. Therefore, reexamination of the past interpretation results from this point of view was also implemented. As a result, the AR and D areas for FY2008-2011 were recalculated. In response to this revision, FM areas for FY2008-2011were also 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 were recalculated, and N_2O emissions from disturbance associated with land-use conversion to cropland in D activities were recalculated due to revision of D areas converted to cropland. CO_2 emissions from agricultural lime application were also recalculated because the emissions were estimated by applying the ratio of D areas to the total areas of cropland as mentioned in 11.4.1.1.b.c).2). In addition, D areas and correspondent Article 3.4 areas which subject to both D and RV activities were recalculated due to this revision; hence, the areas of RV were also recalculated. As a result, carbon stock changes in all carbon pools in RV were also recalculated. CO_2 emissions from lime application in RV were estimated by multiplying amounts of lime applied per area by areas of subcategories in RV as mentioned in section 11.4.1.1.d.e).2); hence, CO_2 emissions from lime application were also recalculated due to the revision of RV areas. Moreover, ratios of disaggregating damaged timber volume from national to prefecture were estimated by utilizing AR, D and FM areas. Hence, CH_4 and N_2O emissions from biomass burning in AR and FM were recalculated because of revision of the ratios of disaggregating amount of damaged timber volume due to revision of AR, D and FM areas.

- ***Correction to removals/emissions by FM activity in accordance with revision of Forest Registers' data***

When Forest Registers' data such as tree species and areas were revised in updates of the Register in order to make them reflect correct status of forests, correction to removals/emissions by FM activities was implemented to obtain appropriate values, because, under the stock change method, it would regard the difference between carbon stock without revision at a point of time and that with revision at another point of time as the carbon stock change between the two points of time. Concretely speaking, the Forest Registers' data were comprehensively revised by reviewing data by 2006 in which estimation of emissions and removals by the stock change method was started. As a result, emissions/removals by FM activities from FY2008 to FY2011 were recalculated.

- ***Reallocation of direct N_2O emissions from N fertilization***

Direct N_2O emissions from N fertilization applied to forest land, which had been reported in agriculture sector in a lump, were reallocated to LULUCF sector by estimating the amount of N fertilization applied to soils in forest land based on information obtained by hearing investigation to prefectures. Therefore, reporting of this category was changed from the notation key “IE” to estimates of the N_2O emissions.

- ***Areas of organic soils in forest land***

Areas of organic soils in forest land were reported as “IE” up until the previous submission because the areas were included in those of mineral soils. From this submission, the areas of organic soils were separated from those of mineral soils by means of data on distribution of organic soils per prefecture as of 2007. The areas of organic soils in forest land are distributed only in semi-natural forests, and intensive silvicultural activities are not implemented to the semi-natural forests that contain organic soils. Therefore, the areas of organic soils were estimated as they exist only in Tennensei-rin forests in forests subject to FM.

11.4.1.5. Uncertainty estimates

As a result of uncertainty assessment implemented by the method provided in annex 7, “7.1 Methodology of uncertainty assessment”, the uncertainty of the total emissions/removals from activities under Articles 3.3 and 3.4 in 2012 has been assessed at 12%.

See relevant sections of chapters 7 and 11 for uncertainties of respective parameters of the LULUCF sector. Specifically, see tables 11-37 to 11-40 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 11-36 Uncertainty of emissions/removals from activities under Articles 3.3 and 3.4 of KP

Greenhouse gas source and sink activities	GHGs	Emissions/Removals [Gg-CO_2 eq.]	%	Emissions/Removals Uncertainty [%]	rank	Emissions/Removals Uncertainty as % of toral national emissions [%]	rank
Article 3.3 activities Afforestation and Reforestation	CO_2, N_2O, CH_4	-494	-1%	37%	1	0%	3
Article 3.3 activities Deforestation	CO_2, N_2O, CH_4	1,955	4%	25%	2	-1%	4
Article 3.4 activities Forest management	CO_2, N_2O, CH_4	-53,141	-101%	12%	4	12%	1
Article 3.4 activities Revegetation	CO_2, N_2O, CH_4	-1,162	-2%	17%	3	0%	2
Total		-52,842	-100%	12%			

11.4.1.5.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 2012 has been assessed at 37%.

Table 11-37 Uncertainty of emissions and removals from afforestation and reforestation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [Gg-CO_2 eq.]	AD Uncertainty [%]	EF/RF Uncertainty [%]	Combined Uncertainty [%]	rank	Combined Uncertainty as % of toral national emissions [%]	rank
Article 3.3 activities Afforestation and Reforestation	Change in carbon pool reported									
		Above-ground biomass	CO_2	-284	9%	43%	44%	4	32%	1
		Below-ground biomass	CO_2	-74	IE	IE	IE	-	IE	-
		Litter	CO_2	-32	-	-	25%	5	2%	3
		Dead wood	CO_2	-93	-	-	97%	1	18%	2
		Soil	CO_2	-11	-	-	25%	6	1%	4
	Greenhouse gas sources reported									
		Fertilization	N_2O	IE	-	-	-	-	-	-
		Drainage of soils under forest management	N_2O	-	-	-	-	-	-	-
		Disturbance associated with land-use conversion to croplands	N_2O	-	-	-	-	-	-	-
		Liming	CO_2	NO	NO	NO	NO	-	-	-
		Biomass burning	CO_2	IE	IE	IE	IE	-	-	-
			CH_4	0	-	-	62%	3	0%	6
			N_2O	0	-	-	64%	2	0%	5
	Total			-494			37%			

11.4.1.5.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 2012 has been assessed at 25%.

Table 11-38 Uncertainty of emissions and removals from deforestation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [Gg-CO_2 eq.]	AD Uncertainty [%]	EF/RF Uncertainty [%]	Combined Uncertainty [%]	rank	Combined Uncertainty as % of toral national emissions [%]	rank
Article 3.3 activities Dforestation	Change in carbon pool reported									
		Above-ground biomass	CO_2	980	9%	26%	27%	4	17%	2
		Below-ground biomass	CO_2	250	IE	IE	IE	-	IE	-
		Litter	CO_2	144	-	-	25%	5	2%	4
		Dead wood	CO_2	358	-	-	97%	1	18%	1
		Soil	CO_2	218	-	-	25%	6	3%	3
	Greenhouse gas sources reported									
		Fertilization	N_2O	-	-	-	-	-	-	-
		Drainage of soils under forest management	N_2O	-	-	-	-	-	-	-
		Disturbance associated with land-use conversion to croplands	N_2O	3	-	-	86%	2	0%	5
		Liming	CO_2	2	-	-	58%	3	0%	6
		Biomass burning	CO_2	NO	NO	NO	NO	-	-	-
			CH_4	NO	NO	NO	NO	-	-	-
			N_2O	NO	NO	NO	NO	-	-	-
	Total			1,955			25%			

11.4.1.5.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 2012 has been assessed at 12%.

Table 11-39 Uncertainty of emissions/removals from forest management activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [Gg-CO_2 eq.]	AD Uncertainty [%]	EF/RF Uncertainty [%]	Combined Uncertainty [%]	rank	Combined Uncertainty as % of toral national emissions [%]	rank
Article 3.4 activities Forest manafement	Change in carbon pool reported									
		Above-ground biomass	CO_2	-42,383	9%	8%	12%	7	12%	1
		Below-ground biomass	CO_2	-10,764	IE	IE	IE	-	IE	-
		Litter	CO_2	-262	-	-	25%	5	0%	3
		Dead wood	CO_2	1,807	-	-	97%	2	-3%	6
		Soil	CO_2	-1,540	-	-	25%	6	1%	2
	Greenhouse gas sources reported									
		Fertilization	N_2O	-	-	-	139%	-	-	-
		Drainage of soils under forest management	N_2O	NO	NO	NO	NO	-	-	-
		Disturbance associated with land-use conversion to croplands	N_2O	-	-	-	-	-	-	-
		Liming	CO_2	NO	NO	NO	NO	-	-	-
		Biomass burning	CO_2	IE	IE	IE	IE	-	-	-
			CH_4	1	-	-	45%	4	0%	5
			N_2O	0	-	-	47%	3	0%	4
	Total			-53,141			12%			

11.4.1.5.d. 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 2012 has been assessed at 17%.

Table 11-40 Uncertainty of emissions/removals from revegetation activities

Greenhouse gas source and sink activities			GHGs	Emissions/ Removals [Gg-CO_2 eq.]	AD Uncertainty [%]	EF/RF Uncertainty [%]	Combined Uncertainty [%]	rank	Combined Uncertainty as % of toral national emissions [%]	rank
Article 3.4 activities Revegetation	Change in carbon pool reported									
		Above-ground biomass	CO_2	-723	-	-	19%	4	15%	1
		Below-ground biomass	CO_2	-188	IE	IE	IE	-	IE	-
		Litter	CO_2	-12	-	-	116%	1	1%	3
		Dead wood	CO_2	IE,NO	IE,NO	IE,NO	IE,NO	-	-	-
		Soil	CO_2	-239	-	-	38%	3	8%	2
	Greenhouse gas sources reported									
		Fertilization	N_2O	IE	IE	IE	IE	-	-	-
		Drainage of soils under forest management	N_2O	-	-	-	-	-	-	-
		Disturbance associated with land-use conversion to croplands	N_2O	-	-	-	-	-	-	-
		Liming	CO_2	0.04	-	-	51%	2	0%	4
		Biomass burning	CO_2	NO	NO	NO	NO	-	-	-
			CH_4	NO	NO	NO	NO	-	-	-
			N_2O	NO	NO	NO	NO	-	-	-
	Total			-1,162			17%			

11.4.1.6. Information on other methodological issues (methods dealing with the effects of natural disturbances[20])

11.4.1.6.a. Afforestation/Reforestation and Deforestation

The effects of natural disturbances have been reflected in forest resources data when Forest Registers are updated every 5 years in each planning area.

11.4.1.6.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.

11.4.1.6.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

[20] Including fires, windstorms, insects, droughts, flooding and ice storms, etc.

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.

11.4.1.7. The year of the onset of an activity, if after 2008

In this submission, all units of land and lands which start to be subject to activities under Article 3.3 or elected activities under Article 3.4 until 2012 are reported. The emissions and removals from the units of land and the lands which start to be subject to the activities in 2012 for the first time are not included in the calculated emissions and removals in 2008-2011. Likewise, the emissions and removals from the units of land and the lands which start to be subject to the activities in 2009, 2010, 2011 and 2012 for the first time are not included in the calculated emissions and removals in the years earlier than those. The areas of such lands are shown below.

Table 11-41 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
FY1990～2012	32.3	343.1	8,376	6,945	15,321
(FY2012)	—	5.5	—	—	—

Table 11-42 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	192	48	0
FY1990-FY2012	52,578	20,956	1,692	649	6
(FY2012)	1,125	330	62	-5	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	199	5,866	
FY1990-FY2012	1,661	293	2,227	80,062	
(FY2012)	31	7	4	1,554	

11.5. Article 3.3

11.5.1. Information that demonstrates that activities under Article 3.3 began on or after 1 January 1990 and before 31 December 2012 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.

11.5.2. 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 70% on average.

11.5.3. Information on the size and geographical location of forest areas that have lost forest cover but which are not yet classified as deforested

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 88 thousand ha in 2012.
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.

11.5.4. Information on emissions and removals of greenhouse gases from lands harvested during the first commitment period following afforestation and reforestation

Japan assumes that all AR units of land have not been harvested during the first commitment period. Therefore, paragraph 4 of the annex to decision 16/CMP.1 is not applied to.

11.6. Article 3.4

11.6.1. Information that demonstrates that activities under Article 3.4 have occurred since 1 January 1990 and are human-induced

11.6.1.1. 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 11.3.2.4.a.b) have been applied to the Tennensei-rin forests continuously after January 1, 1990.

11.6.1.2. Revegetation

Japan demonstrates that RV activities have occurred since 1990 and are human induced based on the following reasons.

Table 11-43 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 control sites	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 [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.

Urban green facilities	Information that demonstrates that Revegetation activities have occurred since 1 January 1990 and are human induced
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.

11.6.2. Information relating to Revegetation for the base year and the commitment period

The anthropogenic greenhouse gas removals in "revegetation" for the base year are those from RV area in 1990. The area where RV activity took place in 1990 is directly obtained by activity data in each subcategory of RV. The anthropogenic greenhouse gas removals in "revegetation" for the commitment period are those from RV area in each year. Those removals are reported within the relevant geographical location. The data and the methodologies used are provided in sections 11.3.2.5 and 11.4.1.1.d.

11.6.3. 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

11.6.3.1.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 11.3.2.2 (see Figure 11-1). Therefore, emissions and removals by FM could not be included in those by AR nor D.

11.6.3.1.b. 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 11.2.2.2. 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 5(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 11.4.1.1.b and those of RV in section 11.4.1.1.d. Therefore, there is no double count between D and RV and emissions and removals from RV could not be included in those from D.

11.6.4. Information relating to Forest Management

11.6.4.1. The definition of forest for this category conforms with the definition in item 11.2 above

In Japan, the area and carbon stock change in land subject to FM activities are estimated by applying FM ratios to data of all forests which meet our country’s forest definition. Therefore, the definition of land subject to FM activities is consistent with our country’s forest definition.

On the other hand, not all managed forests reported under the Convention are subject to FM reported as Article 3.4 activity under the Kyoto Protocol in Japan, because FM forests consist of only the area where FM activities have been taken place since 1990 as described in section 11.3.2.4.

11.6.4.2. The definition of forest management conforms with the definition in paragraph 1 (f) of the Annex to decision 16/CMP.1

Japan considers that FM activities which are reported under the Kyoto Protocol should be of sustainable system and whether this is fulfilled or not is judged from whether appropriate forest practices have been carried out in ikusei-rin forests or whether practices for the protection or conservation of forests such as controlling logging activities and land-use change have been carried out by laws. Therefore, Japan’s definition of FM is consistent with the definition provided in “decision 16/CMP.1” (a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological, economic and social functions of the forest in a sustainable manner).

11.6.4.3. Information on the extent to which GHG removals by sinks offset the debit incurred under Article 3.3.

The total amount of FM removals that offset the debit incurred under Article 3.3 was 9,118 Gg-CO_2 eq. from 2008 until 2012. Related information is provided in Table 11-2.

11.7. Other information

11.7.1. Key category analysis for Article 3.3 activities and any elected activities under Article3.4

In accordance with the *GPG-LULUCF*, Chapter 5, 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 2012 (Annex 1 of this report) are as follows;

5.A.1. Forest land remaining forest land (CO_2)
5.A.2. Land converted to forest land (CO_2)
5.B.2. Land converted to cropland (CO_2)
5.E.2. Land converted to settlements (CO_2)
5.F.2. Land converted to other land (CO_2)

In accordance with *GPG-LULUCF*, AR, D, FM and RV may be identified as key categories under the Kyoto Protocol.

Table 11-44 Relationship between UNFCCC categories and Kyoto Protocol activities

UNFCCC category under the Convention	Kyoto Protocol category
5.A.1. Forest land remaining forest land	FM
5.A.2. Land converted to forest land	AR
5.B.1. Cropland remaining cropland	
5.B.2. Land converted to cropland	D
5.C.1. Grassland remaining grassland	
5.C.2. Land converted to grassland	D
5.D.1. Wetlands remaining wetlands	
5.D.2. Land converted to wetlands	D
5.E.1. Settlements remaining settlements	RV
5.E.2. Land converted to settlements	D、RV
5.F.1. Other land remaining other land	—
5.F.2. Land converted to other land	D

The relationship between conventional categories and the Kyoto categories in this table is based on the *GPG-LULUCF*, p. 5.39, Table 5.4.4., 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 2012 was 1.A.3 Fuel Combustion (Mobile Combustion) a. Civil Aviation (CO_2) [9,524 Gg-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 and RV activities (CO_2) are identified as key activities for 2012.

11.7.2. 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 7 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 11.4.1.5 in chapter 11, and provided additional information in description on each category in chapter 7. Japan will addresses how to systematically show information on uncertainties more disaggregated than those shown in the present NIR as a long-term issue.

11.8. 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.

11.9. Information on the reporting status of paragraphs 5 to 9 of the Annex to decision 15/CMP.1

The requirements for reporting about Articles 3.3 and 3.4 which are set out in paragraphs 5 to 9 of the annex to decision 15/CMP.1 are provided in sections shown in Table 11-45.

Table 11-45 List of reference sections for the requirements set in paragraphs 5 to 9 of the annex to decision 15/CMP.1

Checklist for KP reporting (paragraphs 5-9 in the annex to decision 15/CMP.1)		Paragraph	Main sections of Chapter 11 providing relevant information
Information on how inventory methodologies have been applied taking into account *GPG-LULUCF* and decision 16/CMP.1		6 (a)	Detailed information is provided in each section
Information on the geographical location of the boundaries of areas that encompass:		6 (b)	11.3.3, 11.3.2
	Units of land subject to activities under Article 3.3	6 (b) (i)	11.3.3, 11.3.2
	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	6 (b) (ii)	11.3.3, 11.3.2 and CRF table 5(KP-I)A.2.1
	Land subject to elected activities under Article 3.4	6 (b) (iii)	11.3.3, 11.3.2
Information on the spatial assessment unit for determining the area of accounting for ARD		6 (c)	11.3.1
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.	5	11.4.1: Methodology
	Emissions by sources and removals by sinks are reported for all geographical locations reported in current and previous years	6 (d)	11.3.2.3, 11.3.2.4, 11.3.2.5
	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	6 (d)	11.4.1.7
	Information on which pools (above-ground / below-ground biomass, litter, dead wood and soil organic carbon) were not accounted for.	6 (e)	11.4.1.2
	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.	7	11.4.1.3
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	8 (a)	11.5.1
	Information on how harvesting or forest disturbance that is followed by the re-establishment of forest is distinguished from deforestation	8 (b)	11.5.2, 11.5.3
	Information on emissions/removals from lands harvested during the 1st commitment period following AR on these units of land since 1990.	8 (c)	11.5.4
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.	9 (a)	11.6.2
	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.	9 (b)	11.6.1, 11.3.2.5, 11.4.1.1.d
	Information that emissions/removals from Article 3.4 activities are not accounted for under activities under Article 3.3.	9 (c)	11.6.3
	FM: information on the extent to which GHG removals by sinks offsets the debit incurred under Article 3.3.	9 (d)	11.6.4.3

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6. Ministry of Land, Infrastructure, Transport and Tourism, *Sewage Treatment Facility Status Survey.*
7. Ministry of Land, Infrastructure, Transport and Tourism, *Survey on Carbon Dioxide Absorption at Source in River Works.*
8. Ministry of Land, Infrastructure, Transport and Tourism, *Progress Survey on Tree Planting for Public Rental Housing.*
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22. National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, Japan, *Technical note of National Institute for Land and Infrastructure Management* No.506, The Street tree of Japan VI, 2009.
23. Tonosaki K., Murayama K., Imai K., Nagino Y., *Estimation of Soil Carbon Accumulation Rate in Urban Parks*. Journal of the Japanese Society of Revegetation Technology, Vol. 38 (3), 373-380, 2013.

Chapter 12. Information on accounting of Kyoto units

In line with paragraph 10 of the annex to decision 15/CMP.1, 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 "SEF_JP_2014_1_11-39-42 18-2-2014".

12.1. Summary of information reported in the SEF tables

For information on Kyoto units in Japan's National Registry, see the annex of the NIR "Standard Electric Format for Reporting of Information on Kyoto Protocol Units" (SEF_JP_2014_1_11-39-42 18-2-2014) submitted on the basis of Decision 14/CMP. 1.

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 were discrepancies to be reported. For detailed information on discrepant transaction, see the annex "annex 2-2 disc transaction list 2013" .
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.

[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 afforestaion/reforestation CDM projects, assigned amount units (AAUs) and removal units (RMUs) from KP-LULUCF activities within Annex I Parties.

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
- 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)

According to the paragraph 6 of Annex to Decision 11/CMP.1, each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party’s assigned amount calculated pursuant to Article 3, paragraphs 7 and 8 of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest.

Japan’s commitment period reserve is 5,335,431,899 t-CO_2 eq.[2], which is equivalent to 90% of Japan’s assigned amount and the same as the value reported in the previous submission.

12.5. KP-LULUCF accounting

As stated in the section II.3 of Part 2 of “Report on Japan’s Assigned Amount”, Japan will account for the credits issued by activities under Article 3, paragraphs 3 and 4 of the Kyoto Protocol for the entire commitment period.

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[2] See section I of part 2 of “Report on Japan’s Assigned Amount Pursuant to Article 3, Paragraphs 7 and 8 of the Kyoto Protocol – Under Article 7, paragraph 4 of the Kyoto Protocol, United Nations Framework convention on Climate Change (The Government of Japan, August 2006 (updated in March 2007))” for the calculation of CPR.

Chapter 13. Information on changes in national system

In line with 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, Japan reports changes in national registry of Japan from the previous inventory submission.

14.1. Summary of changes made on national registry of Japan in 2013

Table 14-1 Summary of changes made on national registry of Japan in 2013

Reporting Items	Descriptions of Changes
15/CMP.1, annex II, para 32. (a) Change of name or contact	Contact of the registry system administrator (RSA) of Japan was changed to follows: (Before) Mr. Norihiro Kimura, kimura-norihiro@meti.go.jp (After) Mr. Yoshikazu Hasunuma, hasunuma-yoshikazu@meti.go.jp Ms. Ai Kobayashi, kobayashi-ai@meti.go.jp
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 April 2013, the information for 2012 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 2013, the DNS server and the network device were updated with security patches. Also, the setting for the end of the second commitment period was set to 2020. There is no impact on the functions of the ITL and other national registries.
- In February 2013, a new function was added which allows the Registry System Administrator to conduct retirement and cancellation of selected units which account holders transferred to the governmental holding account. These added functions do not require international communications; therefore, there is no impact on the functions of the ITL and other national registries.
- In April 2013, public information on the unit holdings and transactions conducted was updated on the basis of the SEF for 2012, 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 April 2013, some documents of the Data Exchange Standards for registry systems under the Kyoto Protocol (DES), which were prepared by the secretariat of the UNFCCC, were revised. The revised documents and their impacts on Japan's national registry are described as follows:
  - The DES main text (version 1.1.10) was released.
  - The DES annex E (List of checks and Response Codes for Message Processing, version 1.1.11) was released.
  - The DES annex F (Definition of Identifiers, version 1.3) was released.
  - The DES annex G (List of Codes, version 1.1.3) was released. The new LULUCF activity code, wetland drainage and rewetting, was added to the database of Japan's national registry in September 2013.
- In May 2013, the DNS server was updated with security patches. There is no impact on the functions of the ITL and other national registries.
- In July 2013, the new check which prevents incoming external transfer of units whose applicable commitment period is 2 except for the first external transfer from CDM registry was added. The test was conducted in the test environment to confirm Japan's national registry checks external

transfer based on applicable commitment period, unit type of units involved, and transferring registry.

- In July 2013, the network devices of Japan’s national registry were renewed. Japan’s national registry system administrator requested the ITL to change setting of the ITL in accordance with Japan’s national registry’s new global IP address, and connectivity test was conducted.
- In September 2013, information on Japan’s national registry system administrator was changed.
- In September 2013, middleware and network devises were updated. There is no impact on the functions of the ITL and other national registries.

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, 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 <u>COP</u>, 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. <u>Japan also announced its proactive diplomatic strategy for countering global warming, "Actions for Cool Earth (ACE)", which contributes to the world with its outstanding environmental and energy technologies.</u> In addition, promoting not only further mitigation measures but also adaptation measures taking into account the needs of vulnerable countries leads to maximize the positive impacts of response measures.

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***

Based on the Japan's Cooperation Initiative for Clean Energy and Sustainable Growth presented at the 2nd East Asia Summit in January 2007 and the agreement reached at Asian Ministerial Energy Roundtable held in April 2009, we provided the cooperation in human resource development through accepting trainees and dispatching experts in the area of energy conservation and renewable energy to countries in East Asia and Middle East. We also assisted these countries in the establishment and implementation of legal systems for energy conservation and renewable energy. In addition, in joint policy studies among research institutions from Japan and countries like China and India, we compared country policies related to energy conservation that will benefit the host countries' policy making process and also estimated possibilities of energy use reductions of highly energy-consuming industries.

Additionally, technical assistance in the field of energy and environment by Japan has been provided throughout the world, contributing to the sustainable economic growth of developing countries. As cooperation through Japan International Cooperation Agency (JICA), depending on the needs of developing countries, Japan has been providing assistance in human resource development such as dispatching experts and providing training programs in Japan.

- ***Assistance to oil producing countries in diversifying their economies***

In April 2009, the 3rd Asian Ministerial Energy Roundtable was held in Japan where we requested that regulatory agencies take more coordinated actions to strengthen surveillance on commodity futures trading markets and enhance its transparency for the stabilization of the oil market. Furthermore, parties have agreed to conduct specific projects such as 1) formulation of a demand and supply projection in Asia, 2) sharing of leading projects concerning energy conservation and renewable energy, and 3) provision of training opportunities (e.g., Japan will accept 2000 trainees over 3 years).

- ***Development of carbon capture and storage (CCS) technologies***

Recognizing that CCS is an innovative technology that may achieve highly efficient carbon emissions reductions, Japan has been implementing large-scale demonstration projects toward practical use of CCS by 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 plans to launch survey to identify potential CO_2 storage sites in waters surrounding Japan, study an integrated transportation and storage system based on shuttle shipping, and assess environmental impact of CO_2 absorbent.

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 *Good Practice Guidance (2000)*, and the key category analysis[2] given in the Guidance. The guidelines for national system under Article 5 of the Kyoto Protocol also require countries, in compiling their inventories, to follow the method given in Chapter 7 of the *GPG* and identify the key categories.

The key category analyses were done for both data of FY2012 (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 *GPG* assessment methods (Tier 1 level assessment, Tier 1 trend assessment, Tier 2 level assessment and Tier 2 trend assessment).

The key category for Land use, land use change and forestry (LULUCF) sector were assessed in accordance with *GPG-LULUCF*. The key categories 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, 38 and 35 sources and sinks were detected as the key categories for FY2012 and FY1990, respectively (Table A1-1 and A1-2).

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[1] Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories (following incorporation of the provisions of decision 14/CP.11) (FCCC/SBSTA/2006/9)

[2] The *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (2003), which was welcomed in COP9, extends the key source analysis to LULUCF categories. In the UNFCCC reporting guidelines (FCCC/SBSTA/2004/8) and afterwards, the term “key source category” was revised to “key category”.

Table A1-1 Japan's key categories (FY2012)

	A IPCC Category		**B Direct GHGs**	**L1**	**T1**	**L2**	**T2**
#1	1A Stationary Combustion	Solid Fuels	CO2	#1	#3	#4	#11
#2	1A Stationary Combustion	Liquid Fuels	CO2	#2	#1	#9	#8
#3	1A Stationary Combustion	Gaseous Fuels	CO2	#3	#2		
#4	1A3 Mobile Combustion	b. Road Transportation	CO2	#4	#9	#6	
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	#5	#12	#3	#24
#6	2A Mineral Product	1. Cement Production	CO2	#6	#5	#10	#7
#7	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	#7	#4	#1	#1
#8	1A Stationary Combustion	Other Fuels	CO2	#8	#13	#7	#14
#9	6C Waste Incineration		CO2	#9		#5	#22
#10	1A3 Mobile Combustion	d. Navigation	CO2	#10	#14		
#11	1A3 Mobile Combustion	a. Civil Aviation	CO2	#11			
#12	2A Mineral Product	3. Limestone and Dolomite Use	CO2		#17	#18	#27
#13	4A Enteric Fermentation		CH4			#24	
#14	2A Mineral Product	2. Lime Production	CO2			#21	
#15	4C Rice Cultivation		CH4			#17	#26
#16	1A Stationary Combustion		N2O			#16	#23
#17	4B Manure Management		N2O			#11	
#18	4D Agricultural Soils	1. Direct Soil Emissions	N2O			#8	#12
#19	6A Solid Waste Disposal on Land		CH4		#10	#19	#6
#20	4D Agricultural Soils	3. Indirect Emissions	N2O			#12	#15
#21	4B Manure Management		CH4			#15	#19
#22	1A3 Mobile Combustion	b. Road Transportation	N2O			#14	#10
#23	6C Waste Incineration		N2O			#13	
#24	5E Settlements	2. Land converted to Settlements	CO2		#11		#9
#25	6B Wastewater Handling		CH4				#25
#26	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	PFCs			#23	
#27	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs		#18		#13
#28	6B Wastewater Handling		N2O			#22	
#29	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6		#7		#2
#30	5A Forest Land	2. Land converted to Forest Land	CO2				#20
#31	5F Other Land	2. Land converted to Other Land	CO2				#18
#32	5B Cropland	2. Land converted to Cropland	CO2		#19		#21
#33	2B Chemical Industry	3. Adipic Acid	N2O		#8		#16
#34	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6		#15		#3
#35	1A3 Mobile Combustion	a. Civil Aviation	N2O			#2	#5
#36	1A3 Mobile Combustion	d. Navigation	N2O			#20	
#37	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4		#16		#4
#38	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs		#6		#17

N.B. 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 Direct GHGs**	**L1**	**L2**
#1	1A Stationary Combustion	Liquid Fuels	CO2	#1	#7
#2	1A Stationary Combustion	Solid Fuels	CO2	#2	#4
#3	1A3 Mobile Combustion	b. Road Transportation	CO2	#3	#6
#4	1A Stationary Combustion	Gaseous Fuels	CO2	#4	
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	#5	#1
#6	2A Mineral Product	1. Cement Production	CO2	#6	#9
#7	1A3 Mobile Combustion	d. Navigation	CO2	#7	
#8	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	#8	
#9	6C Waste Incineration		CO2	#9	#3
#10	2A Mineral Product	3. Limestone and Dolomite Use	CO2	#10	#22
#11	1A Stationary Combustion	Other Fuels	CO2	#11	#15
#12	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	#12	#5
#13	6A Solid Waste Disposal on Land		CH4	#13	#13
#14	4A Enteric Fermentation		CH4	#14	#27
#15	2B Chemical Industry	3. Adipic Acid	N2O	#15	
#16	1A3 Mobile Combustion	a. Civil Aviation	CO2	#16	
#17	4C Rice Cultivation		CH4	#17	#19
#18	2A Mineral Product	2. Lime Production	CO2		#25
#19	5E Settlements	2. Land converted to Settlements	CO2		#17
#20	4D Agricultural Soils	1. Direct Soil Emissions	N2O		#8
#21	1A3 Mobile Combustion	b. Road Transportation	N2O		#12
#22	4D Agricultural Soils	3. Indirect Emissions	N2O		#14
#23	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs		#21
#24	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6		#10
#25	2B Chemical Industry	1. Ammonia Production	CO2		#28
#26	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4		#11
#27	4B Manure Management		N2O		#18
#28	4B Manure Management		CH4		#16
#29	6B Wastewater Handling		CH4		#24
#30	5A Forest Land	2. Land converted to Forest Land	CO2		#30
#31	5F Other Land	2. Land converted to Other Land	CO2		#29
#32	6C Waste Incineration		N2O		#20
#33	6B Wastewater Handling		N2O		#26
#34	1A3 Mobile Combustion	d. Navigation	N2O		#23
#35	1A3 Mobile Combustion	a. Civil Aviation	N2O		#2

N.B. Figures recorded in the Level columns indicate the ranking of individual level 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 Tier 1, 90% for Tier 2. Tier 1 level assessment uses emissions and removals from each category directly and Tier 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). In accordance with the *GPG-LULUCF*, 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).

Tier 1 level assessment of the latest emissions and removals (FY2012) gives the following 11 sub-categories as the key categories (Table A1-3). Tier 2 level assessment of the latest emissions and removals (FY2012) gives the following 24 sub-categories as the key categories (Table A1-4).

Table A1-3 Results of Tier 1 level assessment (FY2012)

	A IPCC Category		B Direct GHGs	D Current Year Estimate [Gg-CO_2eq.]	E Level Assessment	F % Contribution to Level	Cumulative
#1	1A Stationary Combustion	Solid Fuels	CO2	431,093.45	0.302	30.2%	30.2%
#2	1A Stationary Combustion	Liquid Fuels	CO2	305,914.57	0.215	21.5%	51.7%
#3	1A Stationary Combustion	Gaseous Fuels	CO2	253,239.32	0.178	17.8%	69.5%
#4	1A3 Mobile Combustion	b. Road Transportation	CO2	196,380.17	0.138	13.8%	83.2%
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	77,324.15	0.054	5.4%	88.7%
#6	2A Mineral Product	1. Cement Production	CO2	25,059.57	0.018	1.8%	90.4%
#7	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	21,920.35	0.015	1.5%	92.0%
#8	1A Stationary Combustion	Other Fuels	CO2	14,012.24	0.010	1.0%	92.9%
#9	6C Waste Incineration		CO2	11,999.93	0.008	0.8%	93.8%
#10	1A3 Mobile Combustion	d. Navigation	CO2	10,850.47	0.008	0.8%	94.5%
#11	1A3 Mobile Combustion	a. Civil Aviation	CO2	9,523.57	0.007	0.7%	95.2%

Table A1-4 Results of Tier 2 level assessment (FY2012)

	A IPCC Category		B Direct GHGs	D Current Year Estimate [Gg-CO_2 eq.]	I Source/Sink Uncertinty	K Contribution to Total L2	Cumulative
#1	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	21,920.35	46%	12.3%	12.3%
#2	1A3 Mobile Combustion	a. Civil Aviation	N2O	96.34	10000%	11.7%	23.9%
#3	5A Forest Land	1. Forest Land remaining Forest Land	CO2	77,324.15	11%	10.2%	34.2%
#4	1A Stationary Combustion	Solid Fuels	CO2	431,093.45	2%	7.9%	42.1%
#5	6C Waste Incineration		CO2	11,999.93	49%	7.2%	49.3%
#6	1A3 Mobile Combustion	b. Road Transportation	CO2	196,380.17	2%	5.5%	54.7%
#7	1A Stationary Combustion	Other Fuels	CO2	14,012.24	25%	4.3%	59.0%
#8	4D Agricultural Soils	1. Direct Soil Emissions	N2O	3,326.98	91%	3.7%	62.7%
#9	1A Stationary Combustion	Liquid Fuels	CO2	305,914.57	1%	3.6%	66.3%
#10	2A Mineral Product	1. Cement Production	CO2	25,059.57	10%	3.2%	69.5%
#11	4B Manure Management		N2O	3,711.92	52%	2.3%	71.9%
#12	4D Agricultural Soils	3. Indirect Emissions	N2O	2,762.65	63%	2.1%	74.0%
#13	6C Waste Incineration		N2O	1,627.79	104%	2.1%	76.1%
#14	1A3 Mobile Combustion	b. Road Transportation	N2O	2,035.51	71%	1.8%	77.8%
#15	4B Manure Management		CH4	2,121.36	66%	1.7%	79.5%
#16	1A Stationary Combustion		N2O	4,063.50	33%	1.6%	81.1%
#17	4C Rice Cultivation		CH4	5,480.40	23%	1.6%	82.7%
#18	2A Mineral Product	3. Limestone and Dolomite Use	CO2	8,034.02	14%	1.3%	84.0%
#19	6A Solid Waste Disposal on Land		CH4	2,927.88	35%	1.2%	85.3%
#20	1A3 Mobile Combustion	d. Navigation	N2O	89.82	1000%	1.1%	86.4%
#21	2A Mineral Product	2. Lime Production	CO2	5,670.13	16%	1.1%	87.4%
#22	6B Wastewater Handling		N2O	1,174.88	75%	1.1%	88.5%
#23	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	PFCs	1,360.63	64%	1.1%	89.6%
#24	4A Enteric Fermentation		CH4	6,378.73	12%	0.9%	90.5%

Tier 1 level assessment of the latest emissions and removals (FY1990) gives the following 17 sub-categories as the key categories (Table A1-5). Tier 2 level assessment of the latest emissions and removals (FY1990) gives the following 30 sub-categories as the key categories (Table A1-6).

Table A1-5 Results of Tier 1 level assessment (FY1990)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO_2eq.]	E level Assessment	F % Contribution to Level	Cumulative
#1	1A Stationary Combustion	Liquid Fuels	CO2	435,168.94	0.328	32.8%	32.8%
#2	1A Stationary Combustion	Solid Fuels	CO2	308,617.28	0.233	23.3%	56.0%
#3	1A3 Mobile Combustion	b. Road Transportation	CO2	189,228.04	0.143	14.3%	70.3%
#4	1A Stationary Combustion	Gaseous Fuels	CO2	104,300.71	0.079	7.9%	78.2%
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76,556.18	0.058	5.8%	83.9%
#6	2A Mineral Product	1. Cement Production	CO2	37,904.87	0.029	2.9%	86.8%
#7	1A3 Mobile Combustion	d. Navigation	CO2	13,730.95	0.010	1.0%	87.8%
#8	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	12,592.30	0.009	0.9%	88.8%
#9	6C Waste Incineration		CO2	12,262.95	0.009	0.9%	89.7%
#10	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10,463.93	0.008	0.8%	90.5%
#11	1A Stationary Combustion	Other Fuels	CO2	9,115.90	0.007	0.7%	91.2%
#12	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8,503.86	0.006	0.6%	91.8%
#13	6A Solid Waste Disposal on Land		CH4	7,637.37	0.006	0.6%	92.4%
#14	4A Enteric Fermentation		CH4	7,549.84	0.006	0.6%	93.0%
#15	2B Chemical Industry	3. Adipic Acid	N2O	7,501.25	0.006	0.6%	93.5%
#16	1A3 Mobile Combustion	a. Civil Aviation	CO2	7,162.41	0.005	0.5%	94.1%
#17	4C Rice Cultivation		CH4	6,959.68	0.005	0.5%	94.6%
#18	2A Mineral Product	2. Lime Production	CO2	6,674.45	0.005	0.5%	95.1%

Table A1-6 Results of Tier 2 level assessment (FY1990)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO_2eq.]	I Source/Sink Uncertinty	K Contribution to Total L2	Cumulative
#1	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76,556.18	11%	9.0%	9.0%
#2	1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	10000%	7.6%	16.6%
#3	6C Waste Incineration		CO2	12,262.95	49%	6.5%	23.1%
#4	1A Stationary Combustion	Solid Fuels	CO2	308,617.28	2%	5.0%	28.2%
#5	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8,503.86	52%	4.8%	33.0%
#6	1A3 Mobile Combustion	b. Road Transportation	CO2	189,228.04	2%	4.7%	37.7%
#7	1A Stationary Combustion	Liquid Fuels	CO2	435,168.94	1%	4.6%	42.3%
#8	4D Agricultural Soils	1. Direct Soil Emissions	N2O	4,544.29	91%	4.5%	46.8%
#9	2A Mineral Product	1. Cement Production	CO2	37,904.87	10%	4.3%	51.0%
#10	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	3,638.23	100%	4.0%	55.0%
#11	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	3,214.33	105%	3.7%	58.7%
#12	1A3 Mobile Combustion	b. Road Transportation	N2O	3,914.04	71%	3.0%	61.7%
#13	6A Solid Waste Disposal on Land		CH4	7,637.37	35%	2.9%	64.6%
#14	4D Agricultural Soils	3. Indirect Emissions	N2O	3,765.00	63%	2.6%	67.2%
#15	1A Stationary Combustion	Other Fuels	CO2	9,115.90	25%	2.5%	69.7%
#16	4B Manure Management		CH4	2,948.72	66%	2.1%	71.8%
#17	5E Settlements	2. Land converted to Settlements	CO2	6,076.47	31%	2.0%	73.8%
#18	4B Manure Management		N2O	3,171.35	52%	1.8%	75.6%
#19	4C Rice Cultivation		CH4	6,959.68	23%	1.8%	77.3%
#20	6C Waste Incineration		N2O	1,493.04	104%	1.7%	79.0%
#21	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	3,725.57	40%	1.6%	80.6%
#22	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10,463.93	14%	1.5%	82.2%
#23	1A3 Mobile Combustion	d. Navigation	N2O	112.87	1000%	1.2%	83.4%
#24	6B Wastewater Handling		CH4	2,402.25	47%	1.2%	84.6%
#25	2A Mineral Product	2. Lime Production	CO2	6,674.45	16%	1.1%	85.8%
#26	6B Wastewater Handling		N2O	1,255.52	75%	1.0%	86.8%
#27	4A Enteric Fermentation		CH4	7,549.84	12%	1.0%	87.7%
#28	2B Chemical Industry	1. Ammonia Production	CO2	3,384.68	23%	0.8%	88.6%
#29	5F Other Land	2. Land converted to Other Land	CO2	1,950.14	40%	0.8%	89.4%
#30	5A Forest Land	2. Land converted to Forest Land	CO2	2,006.49	38%	0.8%	90.2%

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 of which the proportion to the total of trend assessment values is the largest, until the total reaches 95% for Tier 1, 90% for Tier 2. At this point, these categories are defined as the key categories. Tier 1 level assessment uses emissions and removals from each category directly and Tier 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). In accordance with the *GPG-LULUCF*, 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).

Tier 1 trend assessment of the latest emissions and removals (FY2012) gives the following 19 sub-categories as the key categories (Table A1-7). Tier 2 trend assessment of the latest emissions and removals (FY2012) gives the following 27 sub-categories as the key categories (Table A1-8).

Table A1-7 Results of Tier 1 trend assessment (FY2012)

	A IPCC Category		**B Direct GHGs**	**C FY1990 Estimate [Gg-CO_2 eq.]**	**D Current Year Estimate [Gg-CO_2 eq.]**	**H % Contribution to Trend**	**Cumulative**
#1	1A Stationary Combustion	Liquid Fuels	CO2	435169	305915	30.9%	30.9%
#2	1A Stationary Combustion	Gaseous Fuels	CO2	104301	253239	27.0%	58.0%
#3	1A Stationary Combustion	Solid Fuels	CO2	308617	431093	19.1%	77.1%
#4	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	0	21920	0.0%	77.1%
#5	2A Mineral Product	1. Cement Production	CO2	37905	25060	3.0%	80.1%
#6	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	12592	14	2.6%	82.6%
#7	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8504	754	1.6%	84.2%
#8	2B Chemical Industry	3. Adipic Acid	N2O	7501	157	1.5%	85.8%
#9	1A3 Mobile Combustion	b. Road Transportation	CO2	189228	196380	1.3%	87.1%
#10	6A Solid Waste Disposal on Land		CH4	7637	2928	1.0%	88.1%
#11	5E Settlements	2. Land converted to Settlements	CO2	6076	1477	1.0%	89.1%
#12	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76556	77324	0.9%	90.0%
#13	1A Stationary Combustion	Other Fuels	CO2	9116	14012	0.8%	90.8%
#14	1A3 Mobile Combustion	d. Navigation	CO2	13731	10850	0.7%	91.6%
#15	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	3638	129	0.7%	92.3%
#16	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	3214	35	0.7%	92.9%
#17	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10464	8034	0.6%	93.6%
#18	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	3726	1266	0.5%	94.1%
#19	5B Cropland	2. Land converted to Cropland	CO2	2585	180	0.5%	94.6%
#20	1A3 Mobile Combustion	b. Road Transportation	N2O	3914	2036	0.4%	95.0%
#21	4C Rice Cultivation		CH4	6960	5480	0.4%	95.4%

Table A1-8 Results of Tier 2 trend assessment (FY2012)

	A **IPCC Category**		**B** **Direct GHGs**	**C** **FY1990 Estimate [Gg-CO_2 eq.]**	**D** **Current Year Estimate [Gg-CO_2 eq.]**	**I** **Source/Sink Uncertinty**	**M** **Contribution to Total T2**	**Cumulative**
#1	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	0.00	21,920.35	46%	20.1%	20.1%
#2	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8,503.86	753.58	52%	8.7%	28.8%
#3	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	3,638.23	129.06	100%	7.6%	36.3%
#4	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	3,214.33	34.70	105%	7.2%	43.5%
#5	1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	96.34	10000%	4.3%	47.7%
#6	6A Solid Waste Disposal on Land		CH4	7,637.37	2,927.88	35%	3.7%	51.4%
#7	2A Mineral Product	1. Cement Production	CO2	37,904.87	25,059.57	10%	3.3%	54.7%
#8	1A Stationary Combustion	Liquid Fuels	CO2	435,168.94	305,914.57	1%	3.1%	57.8%
#9	5E Settlements	2. Land converted to Settlements	CO2	6,076.47	1,476.95	31%	3.1%	60.8%
#10	1A3 Mobile Combustion	b. Road Transportation	N2O	3,914.04	2,035.51	71%	3.1%	63.9%
#11	1A Stationary Combustion	Solid Fuels	CO2	308,617.28	431,093.45	2%	3.0%	66.9%
#12	4D Agricultural Soils	1. Direct Soil Emissions	N2O	4,544.29	3,326.98	91%	2.8%	69.7%
#13	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	3,725.57	1,266.47	40%	2.2%	71.9%
#14	1A Stationary Combustion	Other Fuels	CO2	9,115.90	14,012.24	25%	2.1%	74.0%
#15	4D Agricultural Soils	3. Indirect Emissions	N2O	3,765.00	2,762.65	63%	1.6%	75.7%
#16	2B Chemical Industry	3. Adipic Acid	N2O	7,501.25	156.76	9%	1.4%	77.1%
#17	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	12,592.30	14.04	5%	1.4%	78.6%
#18	5F Other Land	2. Land converted to Other Land	CO2	1,950.14	288.96	40%	1.4%	80.0%
#19	4B Manure Management		CH4	2,948.72	2,121.36	66%	1.4%	81.4%
#20	5A Forest Land	2. Land converted to Forest Land	CO2	2,006.49	348.59	38%	1.4%	82.7%
#21	5B Cropland	2. Land converted to Cropland	CO2	2,585.24	179.99	25%	1.3%	84.0%
#22	6C Waste Incineration		CO2	12,262.95	11,999.93	49%	1.1%	85.2%
#23	1A Stationary Combustion		N2O	2,164.43	4,063.50	33%	1.1%	86.3%
#24	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76,556.18	77,324.15	11%	1.1%	87.4%
#25	6B Wastewater Handling		CH4	2,402.25	1,463.83	47%	1.0%	88.4%
#26	4C Rice Cultivation		CH4	6,959.68	5,480.40	23%	0.9%	89.3%
#27	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10,463.93	8,034.02	14%	0.9%	90.2%

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 (FY2012)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg CO2eq.]	D Current Year Estimate [Gg CO2eq.]	E Level Assessment	F % Contribution to Level	G Trend Assessment	H % Contribution to Trend	I Source/Sink Uncertainty	J Level Uncertainty (x 1000)	K Contribution to Total L2	L Trend Uncertainty (x 1000)	M Contribution to Total T2
#1	1A Stationary Combustion	Liquid Fuels	CO2	435,168.94	305,914.57	0.215	21.5%	0.1055	29.7%	1%	2.08	0.04	1.02	0.03
#2	1A Stationary Combustion	Solid Fuels	CO2	308,617.28	431,093.45	0.302	30.2%	0.0650	18.3%	2%	4.57	0.08	0.98	0.03
#3	1A Stationary Combustion	Gaseous Fuels	CO2	104,300.71	253,239.32	0.178	17.8%	0.0922	25.9%	0%	0.51	0.01	0.26	0.01
#4	1A Stationary Combustion	Other Fuels	CO2	9,115.90	14,012.24	0.010	1.0%	0.0028	0.8%	25%	2.49	0.04	0.70	0.02
#5	1A Stationary Combustion		CH4	543.30	683.77	0.000	0.0%	0.0001	0.0%	47%	0.23	0.00	0.03	0.00
#6	1A Stationary Combustion		N2O	2,164.43	4,063.50	0.003	0.3%	0.0011	0.3%	33%	0.94	0.02	0.37	0.01
#7	1A Stationary Combustion		CH4	49.20	81.91	0.000	0.0%	0.0000	0.0%	116%	0.07	0.00	0.02	0.00
#8	1A Stationary Combustion		N2O	385.39	337.33	0.000	0.0%	0.0001	0.0%	36%	0.09	0.00	0.02	0.00
#9	1A3 Mobile Combustion	a. Civil Aviation	CO2	7,162.41	9,523.57	0.007	0.7%	0.0012	0.3%	3%	0.17	0.00	0.03	0.00
#10	1A3 Mobile Combustion	b. Road Transportation	CO2	189,228.04	196,380.17	0.138	13.8%	0.0045	1.3%	2%	3.17	0.05	0.10	0.00
#11	1A3 Mobile Combustion	c. Railways	CO2	935.40	554.35	0.000	0.0%	0.0003	0.1%	2%	0.01	0.00	0.01	0.00
#12	1A3 Mobile Combustion	d. Navigation	CO2	13,730.95	10,850.47	0.008	0.8%	0.0025	0.7%	2%	0.18	0.00	0.06	0.00
#13	1A3 Mobile Combustion	a. Civil Aviation	CH4	2.94	4.98	0.000	0.0%	0.0000	0.0%	200%	0.01	0.00	0.00	0.00
#14	1A3 Mobile Combustion	b. Road Transportation	CH4	263.88	127.74	0.000	0.0%	0.0001	0.0%	64%	0.06	0.00	0.07	0.00
#15	1A3 Mobile Combustion	c. Railways	CH4	1.10	0.64	0.000	0.0%	0.0000	0.0%	10%	0.00	0.00	0.00	0.00
#16	1A3 Mobile Combustion	d. Navigation	CH4	26.76	21.30	0.000	0.0%	0.0000	0.0%	200%	0.03	0.00	0.01	0.00
#17	1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	96.34	0.000	0.0%	0.0000	0.0%	10000%	6.76	0.12	1.40	0.04
#18	1A3 Mobile Combustion	b. Road Transportation	N2O	3,914.04	2,035.51	0.001	0.1%	0.0014	0.4%	71%	1.01	0.02	1.00	0.03
#19	1A3 Mobile Combustion	c. Railways	N2O	121.22	70.38	0.000	0.0%	0.0000	0.0%	11%	0.01	0.00	0.00	0.00
#20	1A3 Mobile Combustion	d. Navigation	N2O	112.87	89.82	0.000	0.0%	0.0000	0.0%	1000%	0.63	0.01	0.21	0.01
#21	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	3,214.33	34.70	0.000	0.0%	0.0022	0.6%	105%	0.03	0.00	2.35	0.07
#22	1B Fugitive Emission	1a ii. Coal Mining and Handling (surface)	CH4	21.20	12.64	0.000	0.0%	0.0000	0.0%	185%	0.02	0.00	0.01	0.00
#23	1B Fugitive Emission	2a. Oil	CO2	0.14	0.09	0.000	0.0%	0.0000	0.0%	23%	0.00	0.00	0.00	0.00
#24	1B Fugitive Emission	2a. Oil	CH4	28.32	23.35	0.000	0.0%	0.0000	0.0%	17%	0.00	0.00	0.00	0.00
#25	1B Fugitive Emission	2a. Oil	N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	27%	0.00	0.00	0.00	0.00
#26	1B Fugitive Emission	2b. Natural Gas	CO2	0.25	0.39	0.000	0.0%	0.0000	0.0%	25%	0.00	0.00	0.00	0.00
#27	1B Fugitive Emission	2b. Natural Gas	CH4	187.94	283.48	0.000	0.0%	0.0001	0.0%	21%	0.04	0.00	0.01	0.00
#28	1B Fugitive Emission	2c. Venting & Flaring	CO2	36.23	31.23	0.000	0.0%	0.0000	0.0%	18%	0.00	0.00	0.00	0.00
#29	1B Fugitive Emission	2c. Venting & Flaring	CH4	14.45	10.57	0.000	0.0%	0.0000	0.0%	20%	0.00	0.00	0.00	0.00
#30	1B Fugitive Emission	2c. Venting & Flaring	N2O	0.11	0.10	0.000	0.0%	0.0000	0.0%	18%	0.00	0.00	0.00	0.00
#31	2A Mineral Product	1. Cement Production	CO2	37,904.87	25,059.57	0.018	1.8%	0.0102	2.9%	10%	1.84	0.03	1.07	0.03
#32	2A Mineral Product	2. Lime Production	CO2	6,674.45	5,670.13	0.004	0.4%	0.0010	0.3%	16%	0.63	0.01	0.15	0.00
#33	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10,463.93	8,034.02	0.006	0.6%	0.0021	0.6%	14%	0.77	0.01	0.29	0.01
#34	2A Mineral Product	4. Soda Ash Production and Use	CO2	267.28	142.26	0.000	0.0%	0.0001	0.0%	16%	0.02	0.00	0.02	0.00
#35	2B Chemical Industry	1. Ammonia Production	CO2	3,384.68	1,837.56	0.001	0.1%	0.0012	0.3%	23%	0.30	0.01	0.27	0.01
#36	2B Chemical Industry	other products except Anmonia	CO2	824.39	578.12	0.000	0.0%	0.0002	0.1%	77%	0.31	0.01	0.16	0.00
#37	2B Chemical Industry	2. Nitric Acid	N2O	765.70	474.57	0.000	0.0%	0.0002	0.1%	46%	0.15	0.00	0.11	0.00
#38	2B Chemical Industry	3. Adipic Acid	N2O	7,501.25	156.76	0.000	0.0%	0.0052	1.5%	9%	0.01	0.00	0.48	0.01
#39	2B Chemical Industry	whole of Chemical Industries	CH4	338.05	104.33	0.000	0.0%	0.0002	0.0%	99%	0.07	0.00	0.17	0.01
#40	2C Metal Production	1 Iron and Steel Production	CO2	356.09	174.20	0.000	0.0%	0.0001	0.0%	5%	0.01	0.00	0.01	0.00
#41	2C Metal Production	1 Iron and Steel Production	CH4	15.47	12.49	0.000	0.0%	0.0000	0.0%	163%	0.01	0.00	0.00	0.00
#42	2C Metal Production	2. Ferroalloys Production	CH4	3.89	2.70	0.000	0.0%	0.0000	0.0%	163%	0.00	0.00	0.00	0.00
#43	2C Metal Production	3. Aluminium Production	PFCs	137.15	9.02	0.000	0.0%	0.0001	0.0%	33%	0.00	0.00	0.03	0.00
#44	2C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	SF6	153.61	191.20	0.000	0.0%	0.0000	0.0%	5%	0.01	0.00	0.00	0.00
#45	2C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	HFCs	0.00	1.17	0.000	0.0%	0.0000	0.0%	5%	0.00	0.00	0.00	0.00
#46	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	12,592.30	14.04	0.000	0.0%	0.0088	2.5%	5%	0.00	0.00	0.48	0.01
#47	2E Production of Halocarbons and SF6	2. Fugitive Emissions	HFCs	1.30	78.38	0.000	0.0%	0.0001	0.0%	100%	0.06	0.00	0.05	0.00
#48	2E Production of Halocarbons and SF6	2. Fugitive Emissions	PFCs	276.08	122.16	0.000	0.0%	0.0001	0.0%	100%	0.09	0.00	0.11	0.00
#49	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	3,638.23	129.06	0.000	0.0%	0.0025	0.7%	100%	0.09	0.00	2.48	0.08
#50	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	0.00	21,920.35	0.015	1.5%	0.0143	4.0%	46%	7.08	0.12	6.59	0.20
#51	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	2. Foam Blowing	HFCs	1.22	294.47	0.000	0.0%	0.0002	0.1%	50%	0.10	0.00	0.10	0.00
#52	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	3. Fire Extinguishers	HFCs	0.00	7.01	0.000	0.0%	0.0000	0.0%	64%	0.00	0.00	0.00	0.00
#53	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	4. Aerosols/ Metered Dose Inhalers	HFCs	0.00	534.47	0.000	0.0%	0.0003	0.1%	26%	0.10	0.00	0.09	0.00
#54	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	3,725.57	1,266.47	0.001	0.1%	0.0018	0.5%	40%	0.36	0.01	0.71	0.02
#55	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	HFCs	0.43	75.81	0.000	0.0%	0.0000	0.0%	64%	0.03	0.00	0.03	0.00
#56	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	PFCs	1,137.91	1,360.63	0.001	0.1%	0.0001	0.0%	64%	0.61	0.01	0.06	0.00
#57	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	SF6	872.15	511.25	0.000	0.0%	0.0003	0.1%	64%	0.23	0.00	0.18	0.01
#58	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8,503.86	753.58	0.001	0.1%	0.0055	1.5%	52%	0.28	0.00	2.85	0.09
#59	2F(a) Consumption of Halocarbons	9. Other - Railway Silicon Rectifiers	PFCs	0.00	0.00	0.000	0.0%	0.0000	0.0%	40%	0.00	0.00	0.00	0.00
#60	3 Solvent & Other Product Use	Using Laughing Gas in Hospital	N2O	287.07	90.68	0.000	0.0%	0.0001	0.0%	5%	0.00	0.00	0.01	0.00
#61	4A Enteric Fermentation		CH4	7,549.84	6,378.73	0.004	0.4%	0.0011	0.3%	12%	0.52	0.01	0.13	0.00
#62	4B Manure Management		CH4	2,948.72	2,121.36	0.001	0.1%	0.0007	0.2%	66%	0.99	0.02	0.45	0.01
#63	4B Manure Management		N2O	3,171.35	3,711.92	0.003	0.3%	0.0002	0.1%	52%	1.36	0.02	0.10	0.00
#64	4C Rice Cultivation		CH4	6,959.68	5,480.40	0.004	0.4%	0.0013	0.4%	23%	0.90	0.02	0.30	0.01
#65	4D Agricultural Soils	1. Direct Soil Emissions	N2O	4,544.29	3,326.98	0.002	0.2%	0.0010	0.3%	91%	2.13	0.04	0.93	0.03
#66	4D Agricultural Soils	2. Pasture, Range and Paddock Manure	N2O	67.91	50.26	0.000	0.0%	0.0000	0.0%	133%	0.05	0.00	0.02	0.00
#67	4D Agricultural Soils	3. Indirect Emissions	N2O	3,765.00	2,762.65	0.002	0.2%	0.0008	0.2%	63%	1.23	0.02	0.53	0.02
#68	4F Field Burning of Agricultural Residues		CH4	100.68	56.71	0.000	0.0%	0.0000	0.0%	224%	0.09	0.00	0.08	0.00
#69	4F Field Burning of Agricultural Residues		N2O	27.25	15.74	0.000	0.0%	0.0000	0.0%	180%	0.02	0.00	0.02	0.00
#70	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76,556.18	77,324.15	0.054	5.4%	0.0032	0.9%	11%	5.92	0.10	0.35	0.01
#71	5A Forest Land	2. Land converted to Forest Land	CO2	2,006.49	348.59	0.000	0.0%	0.0012	0.3%	38%	0.09	0.00	0.45	0.01
#72	5A Forest Land		CH4	8.51	1.59	0.000	0.0%	0.0000	0.0%	45%	0.00	0.00	0.00	0.00
#73	5A Forest Land		N2O	1.73	0.71	0.000	0.0%	0.0000	0.0%	108%	0.00	0.00	0.00	0.00
#74	5B Cropland	1. Cropland remaining Cropland	CO2	1,602.96	1,461.22	0.001	0.1%	0.0002	0.0%	0%	0.00	0.00	0.00	0.00
#75	5B Cropland	2. Land converted to Cropland	CO2	2,585.24	179.99	0.000	0.0%	0.0017	0.5%	25%	0.03	0.00	0.43	0.01
#76	5B Cropland		CH4	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#77	5B Cropland		N2O	70.28	3.98	0.000	0.0%	0.0000	0.0%	82%	0.00	0.00	0.04	0.00
#78	5C Grassland	1. Grassland remaining Grassland	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#79	5C Grassland	2. Land converted to Grassland	CO2	230.99	116.01	0.000	0.0%	0.0001	0.0%	97%	0.08	0.00	0.08	0.00
#80	5C Grassland		CH4	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#81	5C Grassland		N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#82	5D Wetlands	1. Wetlands remaining Wetlands	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#83	5D Wetlands	2. Land converted to Wetlands	CO2	90.94	31.83	0.000	0.0%	0.0000	0.0%	29%	0.01	0.00	0.01	0.00
#84	5D Wetlands		CH4	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#85	5D Wetlands		N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#86	5E Settlements	1. Settlements remaining Settlements	CO2	960.76	968.62	0.001	0.1%	0.0000	0.0%	35%	0.23	0.00	0.01	0.00
#87	5E Settlements	2. Land converted to Settlements	CO2	6,076.47	1,476.95	0.001	0.1%	0.0033	0.9%	31%	0.32	0.01	1.01	0.03
#88	5E Settlements		CH4	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#89	5E Settlements		N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#90	5F Other Land	1. Other Land remaining Other Land	CO2	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#91	5F Other Land	2. Land converted to Other Land	CO2	1,950.14	288.96	0.000	0.0%	0.0012	0.3%	40%	0.08	0.00	0.47	0.01
#92	5F Other Land		CH4	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#93	5F Other Land		N2O	0.00	0.00	0.000	0.0%	0.0000	0.0%	0%	0.00	0.00	0.00	0.00
#94	5G Other	CO2 emissions from agricultural lime application	CO2	550.24	246.78	0.000	0.0%	0.0002	0.1%	51%	0.09	0.00	0.11	0.00
#95	6A Solid Waste Disposal on Land		CH4	7,637.37	2,927.88	0.002	0.2%	0.0034	1.0%	35%	0.72	0.01	1.20	0.04
#96	6B Wastewater Handling		CH4	2,402.25	1,463.83	0.001	0.1%	0.0007	0.2%	47%	0.48	0.01	0.34	0.01
#97	6B Wastewater Handling		N2O	1,255.52	1,174.88	0.001	0.1%	0.0001	0.0%	75%	0.62	0.01	0.09	0.00
#98	6C Waste Incineration		CO2	12,262.95	11,999.93	0.008	0.8%	0.0008	0.2%	49%	4.14	0.07	0.38	0.01
#99	6C Waste Incineration		CH4	13.48	8.42	0.000	0.0%	0.0000	0.0%	111%	0.01	0.00	0.00	0.00
#100	6C Waste Incineration		N2O	1,493.04	1,627.79	0.001	0.1%	0.0000	0.0%	104%	1.19	0.02	0.02	0.00
#101	6D Other		CO2	702.83	515.07	0.000	0.0%	0.0002	0.0%	25%	0.09	0.00	0.04	0.00
#102	6D Other		CH4	92.01	164.83	0.000	0.0%	0.0000	0.0%	74%	0.09	0.00	0.03	0.00
#103	6D Other		N2O	81.50	146.00	0.000	0.0%	0.0000	0.0%	86%	0.09	0.00	0.03	0.00
	TOTAL			1,327,011.08	1,425,567.12	1.00	100.0%	0.36	100.0%		57.78	1.00	32.81	1.00

Table A1-10 Data used for the key category analysis (FY1990)

	A IPCC Category		B Direct GHGs	C FY1990 Estimate [Gg-CO_2eq.]	E Level Assessment	F % Contribution to Level	I Source/Sink Uncertainty	J Level Uncertainty (x 1000)	K Contribution to Total L2
#1	1A Stationary Combustion	Liquid Fuels	CO2	435,168.94	0.328	32.8%	1%	3.18	0.05
#2	1A Stationary Combustion	Solid Fuels	CO2	308,617.28	0.233	23.3%	2%	3.51	0.05
#3	1A Stationary Combustion	Gaseous Fuels	CO2	104,300.71	0.079	7.9%	0%	0.22	0.00
#4	1A Stationary Combustion	Other Fuels	CO2	9,115.90	0.007	0.7%	25%	1.74	0.03
#5	1A Stationary Combustion		CH4	543.30	0.000	0.0%	47%	0.19	0.00
#6	1A Stationary Combustion		N2O	2,164.43	0.002	0.2%	33%	0.54	0.01
#7	1A Stationary Combustion		CH4	49.20	0.000	0.0%	116%	0.04	0.00
#8	1A Stationary Combustion		N2O	385.39	0.000	0.0%	36%	0.11	0.00
#9	1A3 Mobile Combustion	a. Civil Aviation	CO2	7,162.41	0.005	0.5%	3%	0.14	0.00
#10	1A3 Mobile Combustion	b. Road Transportation	CO2	189,228.04	0.143	14.3%	2%	3.28	0.05
#11	1A3 Mobile Combustion	c. Railways	CO2	935.40	0.001	0.1%	2%	0.02	0.00
#12	1A3 Mobile Combustion	d. Navigation	CO2	13,730.95	0.010	1.0%	2%	0.25	0.00
#13	1A3 Mobile Combustion	a. Civil Aviation	CH4	2.94	0.000	0.0%	200%	0.00	0.00
#14	1A3 Mobile Combustion	b. Road Transportation	CH4	263.88	0.000	0.0%	64%	0.13	0.00
#15	1A3 Mobile Combustion	c. Railways	CH4	1.10	0.000	0.0%	10%	0.00	0.00
#16	1A3 Mobile Combustion	d. Navigation	CH4	26.76	0.000	0.0%	200%	0.04	0.00
#17	1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	0.000	0.0%	10000%	5.26	0.08
#18	1A3 Mobile Combustion	b. Road Transportation	N2O	3,914.04	0.003	0.3%	71%	2.09	0.03
#19	1A3 Mobile Combustion	c. Railways	N2O	121.22	0.000	0.0%	11%	0.01	0.00
#20	1A3 Mobile Combustion	d. Navigation	N2O	112.87	0.000	0.0%	1000%	0.85	0.01
#21	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	3,214.33	0.002	0.2%	105%	2.55	0.04
#22	1B Fugitive Emission	1a ii. Coal Mining and Handling (surface)	CH4	21.20	0.000	0.0%	185%	0.03	0.00
#23	1B Fugitive Emission	2a. Oil	CO2	0.14	0.000	0.0%	23%	0.00	0.00
#24	1B Fugitive Emission	2a. Oil	CH4	28.32	0.000	0.0%	17%	0.00	0.00
#25	1B Fugitive Emission	2a. Oil	N2O	0.00	0.000	0.0%	27%	0.00	0.00
#26	1B Fugitive Emission	2b. Natural Gas	CO2	0.25	0.000	0.0%	25%	0.00	0.00
#27	1B Fugitive Emission	2b. Natural Gas	CH4	187.94	0.000	0.0%	21%	0.03	0.00
#28	1B Fugitive Emission	2c. Venting & Flaring	CO2	36.23	0.000	0.0%	18%	0.01	0.00
#29	1B Fugitive Emission	2c. Venting & Flaring	CH4	14.45	0.000	0.0%	20%	0.00	0.00
#30	1B Fugitive Emission	2c. Venting & Flaring	N2O	0.11	0.000	0.0%	18%	0.00	0.00
#31	2A Mineral Product	1. Cement Production	CO2	37,904.87	0.029	2.9%	10%	2.98	0.04
#32	2A Mineral Product	2. Lime Production	CO2	6,674.45	0.005	0.5%	16%	0.80	0.01
#33	2A Mineral Product	3. Limestone and Dolomite Use	CO2	10,463.93	0.008	0.8%	14%	1.08	0.02
#34	2A Mineral Product	4. Soda Ash Production and Use	CO2	267.28	0.000	0.0%	16%	0.03	0.00
#35	2B Chemical Industry	1. Ammonia Production	CO2	3,384.68	0.003	0.3%	23%	0.59	0.01
#36	2B Chemical Industry	other products except Anmonia	CO2	824.39	0.001	0.1%	77%	0.48	0.01
#37	2B Chemical Industry	2. Nitric Acid	N2O	765.70	0.001	0.1%	46%	0.27	0.00
#38	2B Chemical Industry	3. Adipic Acid	N2O	7,501.25	0.006	0.6%	9%	0.52	0.01
#39	2B Chemical Industry	whole of Chemical Industries	CH4	338.05	0.000	0.0%	99%	0.25	0.00
#40	2C Metal Production	1 Iron and Steel Production	CO2	356.09	0.000	0.0%	5%	0.01	0.00
#41	2C Metal Production	1 Iron and Steel Production	CH4	15.47	0.000	0.0%	163%	0.02	0.00
#42	2C Metal Production	2. Ferroalloys Production	CH4	3.89	0.000	0.0%	163%	0.00	0.00
#43	2C Metal Production	3. Aluminium Production	PFCs	137.15	0.000	0.0%	33%	0.03	0.00
#44	2C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	SF6	153.61	0.000	0.0%	5%	0.01	0.00
#45	2C Metal Production	4. SF6 Used in Aluminium and Magnesium oundries	HFCs	0.00	0.000	0.0%	5%	0.00	0.00
#46	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	12,592.30	0.009	0.9%	5%	0.51	0.01
#47	2E Production of Halocarbons and SF6	2. Fugitive Emissions	HFCs	1.30	0.000	0.0%	100%	0.00	0.00
#48	2E Production of Halocarbons and SF6	2. Fugitive Emissions	PFCs	276.08	0.000	0.0%	100%	0.21	0.00
#49	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	3,638.23	0.003	0.3%	100%	2.76	0.04
#50	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	0.00	0.000	0.0%	46%	0.00	0.00
#51	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	2. Foam Blowing	HFCs	1.22	0.000	0.0%	50%	0.00	0.00
#52	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	3. Fire Extinguishers	HFCs	0.00	0.000	0.0%	64%	0.00	0.00
#53	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	4. Aerosols/ Metered Dose Inhalers	HFCs	0.00	0.000	0.0%	26%	0.00	0.00
#54	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	3,725.57	0.003	0.3%	40%	1.12	0.02
#55	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	HFCs	0.43	0.000	0.0%	64%	0.00	0.00
#56	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	PFCs	1,137.91	0.001	0.1%	64%	0.55	0.01
#57	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	7. Semiconductor Manufacture	SF6	872.15	0.001	0.1%	64%	0.42	0.01
#58	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	8,503.86	0.006	0.6%	52%	3.33	0.05
#59	2F(a) Consumption of Halocarbons	9. Other - Railway Silicon Rectifiers	PFCs	0.00	0.000	0.0%	40%	0.00	0.00
#60	3 Solvent & Other Product Use	Using Laughing Gas in Hospital	N2O	287.07	0.000	0.0%	5%	0.01	0.00
#61	4A Enteric Fermentation		CH4	7,549.84	0.006	0.6%	12%	0.67	0.01
#62	4B Manure Management		CH4	2,948.72	0.002	0.2%	66%	1.47	0.02
#63	4B Manure Management		N2O	3,171.35	0.002	0.2%	52%	1.24	0.02
#64	4C Rice Cultivation		CH4	6,959.68	0.005	0.5%	23%	1.22	0.02
#65	4D Agricultural Soils	1. Direct Soil Emissions	N2O	4,544.29	0.003	0.3%	91%	3.13	0.04
#66	4D Agricultural Soils	2. Pasture, Range and Paddock Manure	N2O	67.91	0.000	0.0%	133%	0.07	0.00
#67	4D Agricultural Soils	3. Indirect Emissions	N2O	3,765.00	0.003	0.3%	63%	1.80	0.03
#68	4F Field Burning of Agricultural Residues		CH4	100.68	0.000	0.0%	224%	0.17	0.00
#69	4F Field Burning of Agricultural Residues		N2O	27.25	0.000	0.0%	180%	0.04	0.00
#70	5A Forest Land	1. Forest Land remaining Forest Land	CO2	76,556.18	0.058	5.8%	11%	6.30	0.09
#71	5A Forest Land	2. Land converted to Forest Land	CO2	2,006.49	0.002	0.2%	38%	0.57	0.01
#72	5A Forest Land		CH4	8.51	0.000	0.0%	45%	0.00	0.00
#73	5A Forest Land		N2O	1.73	0.000	0.0%	108%	0.00	0.00
#74	5B Cropland	1. Cropland remaining Cropland	CO2	1,602.96	0.001	0.1%	0%	0.00	0.00
#75	5B Cropland	2. Land converted to Cropland	CO2	2,585.24	0.002	0.2%	25%	0.49	0.01
#76	5B Cropland		CH4	0.00	0.000	0.0%	0%	0.00	0.00
#77	5B Cropland		N2O	70.28	0.000	0.0%	82%	0.04	0.00
#78	5C Grassland	1. Grassland remaining Grassland	CO2	0.00	0.000	0.0%	0%	0.00	0.00
#79	5C Grassland	2. Land converted to Grassland	CO2	230.99	0.000	0.0%	97%	0.17	0.00
#80	5C Grassland		CH4	0.00	0.000	0.0%	0%	0.00	0.00
#81	5C Grassland		N2O	0.00	0.000	0.0%	0%	0.00	0.00
#82	5D Wetlands	1. Wetlands remaining Wetlands	CO2	0.00	0.000	0.0%	0%	0.00	0.00
#83	5D Wetlands	2. Land converted to Wetlands	CO2	90.94	0.000	0.0%	29%	0.02	0.00
#84	5D Wetlands		CH4	0.00	0.000	0.0%	0%	0.00	0.00
#85	5D Wetlands		N2O	0.00	0.000	0.0%	0%	0.00	0.00
#86	5E Settlements	1. Settlements remaining Settlements	CO2	960.76	0.001	0.1%	35%	0.25	0.00
#87	5E Settlements	2. Land converted to Settlements	CO2	6,076.47	0.005	0.5%	31%	1.40	0.02
#88	5E Settlements		CH4	0.00	0.000	0.0%	0%	0.00	0.00
#89	5E Settlements		N2O	0.00	0.000	0.0%	0%	0.00	0.00
#90	5F Other Land	1. Other Land remaining Other Land	CO2	0.00	0.000	0.0%	0%	0.00	0.00
#91	5F Other Land	2. Land converted to Other Land	CO2	1,950.14	0.001	0.1%	40%	0.58	0.01
#92	5F Other Land		CH4	0.00	0.000	0.0%	0%	0.00	0.00
#93	5F Other Land		N2O	0.00	0.000	0.0%	0%	0.00	0.00
#94	5G Other	CO2 emissions from agricultural lime application	CO2	550.24	0.000	0.0%	51%	0.21	0.00
#95	6A Solid Waste Disposal on Land		CH4	7,637.37	0.006	0.6%	35%	2.01	0.03
#96	6B Wastewater Handling		CH4	2,402.25	0.002	0.2%	47%	0.85	0.01
#97	6B Wastewater Handling		N2O	1,255.52	0.001	0.1%	75%	0.71	0.01
#98	6C Waste Incineration		CO2	12,262.95	0.009	0.9%	49%	4.54	0.07
#99	6C Waste Incineration		CH4	13.48	0.000	0.0%	111%	0.01	0.00
#100	6C Waste Incineration		N2O	1,493.04	0.001	0.1%	104%	1.17	0.02
#101	6D Other		CO2	702.83	0.001	0.1%	25%	0.13	0.00
#102	6D Other		CH4	92.01	0.000	0.0%	74%	0.05	0.00
#103	6D Other		N2O	81.50	0.000	0.0%	86%	0.05	0.00
	TOTAL			1,327,011.08	1.00	100.0%		69.58	1.00

A1.2.4. Qualitative Analysis

Key categories identified in the qualitative analysis include the categories in which: mitigation techniques have been employed, significant variance of emissions and removals has been confirmed, a high uncertainty exists due to the solo implementation of the Tier 1 analysis of key categories, unexpectedly high or low estimates are identified, and major changes in the estimation methodology or data have occurred.

In Japan, the categories in which mitigation techniques have been employed, emissions and removals have been newly estimated, and estimation methods have been changed, were identified as key in terms of the qualitative analysis. In this year, the key categories were identified only based on the quantitative results of the level and trend assessments, including both Tier 1 and Tier 2.

Annex 2. Detailed Discussion on Methodology and Data for Estimating CO_2 Emissions from Fossil Fuel Combustion

A2.1. 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 2 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 FY2011 actual data. The IEA statistical data used in the explanation were extracted from the Energy Statistics of OECD Countries 2010–2011, 2013 Edition, OECD/IEA (CD-ROM version).

In summary, these discrepancies occurred because (a) Japan and the IEA treat international aviation and marine bunker fuels differently in their respective energy balances and (b) because of the different classifications of fuel oil A. The IEA energy balances include international aviation and marine bunker fuels; whereas the energy balances of Japan do not include them as these are not regarded as domestic consumption. Consequently, the data for the bonded exports and imports of jet kerosene and fuel oil C are differently accounted for. 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 20 mm^2/s below, carbon residue content of 4% below and sulfur content of 2.0 % below. Fuel oil B has a flash point of more than 60 °C, kinematic viscosity of 50 mm^2/s below, carbon residue content of 8% below and sulfur content of 3.0 % below. 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%.

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 2011>

CRF Table 1.A(b)	IEA statistics
Exports: 8,693.51× 10^3 kl <Breakdown> Exports excluding bonded exports: 2,560.71× 10^3 kl Bonded exports: 6,132.8× 10^3 kl	Exports: 2,007× 10^3 t [2,561× 10^3 kl (exports excluding bonded exports) × 0.7834 t/kl (density) = 2,007× 10^3 t]
	<Remarks 1> Because each exported amount per destination country is rounded off before aggregation in the IEA statistics, the aggregation sometimes differs slightly from the multiplication product of the total exported amount and the density. <Remarks 2> International aviation: 5,810× 10^3 t [6,132.8× 10^3 kl (bonded exports) + 1,283.3× 10^3 kl (bonded imports) = 7,416.1× 10^3 kl; 7,416.1× 10^3 kl × 0.7834 t/kl (density) = 5,810× 10^3 t]

<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 heavy fuel oil in the IEA statistics do not. The bonded exports portion of the heavy fuel oil was reported in the IEA statistics as an aggregate of the bonded exports and imports of heavy 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 2011>

CRF Table 1.A(b)	IEA statistics
Exports: 7,134.75× 10^3 kl [342.26× 10^3 kl (fuel oil A) + 6,792.49× 10^3 kl (fuel oils B and C) = 7,134.75× 10^3 kl]	Exports: 2,589× 10^3 t [2,877.29× 10^3 kl (exports of fuel oils B and C excluding bonded exports) × 0.9 t/kl (density) = 2,590× 10^3 t]
<Breakdown> Exports of fuel oil A: 342.26× 10^3 kl Exports excluding bonded exports: 272.30× 10^3 kl Bonded exports: 69.96× 10^3 kl Exports of fuel oils B and C: 6,792.49× 10^3 kl Exports excluding bonded exports: 2,877.29× 10^3 kl Bonded exports: 3,915.21× 10^3 kl	<Remarks 1> Because each exported amount per destination country is rounded off before aggregation in the IEA statistics, the aggregation sometimes differs slightly from the multiplication product of the total exported amount and the density. <Remarks 2> International marine bunkers: 3,948× 10^3 t [3,915.21× 10^3 kl (bonded exports of fuel oils B and C) + 472.49× 10^3 kl (bonded imports of fuel oils B and C) = 4,387.69× 10^3 kl; 4,387.69× 10^3 kl × 0.9 t/kl (density) = 3,948× 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 2011>

CRF Table 1.A(b)	IEA statistics
Imports: 7,416.13× 10^3 kl <Jet kerosene imports> Imports: 7,416.13× 10^3 kl Imports excluding bonded imports: 0.00× 10^3 kl Bonded imports: 1,283.32× 10^3 kl Bonded exports: 6,132.81× 10^3 kl	Imports: 1,005× 10^3 t [1,283.32× 10^3 kl (imports including bonded imports) × 0.7834 t/kl (density) = 1,005× 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 2011>

CRF Table 1.A(b)	IEA statistics
Imports: 884.54× 10^3 kl <Imports of gas/diesel oil> Imports excluding bonded imports: 874.78× 10^3 kl Bonded imports: 4.87× 10^3 kl Bonded exports: 4.89× 10^3 kl	Imports: 816× 10^3 t [879.65× 10^3 kl (imports of gas/diesel oil including bonded imports) + 88.75× 10^3 kl (imports of fuel oil A including bonded imports) = 968.4× 10^3 kl; 968.4× 10^3 kl × 0.843 t/kl (density) = 816× 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 the CRF and the IEA statistics are the same.

<Reference: Imports of coking coal in 2011>

CRF Table 1.A(b)	IEA statistics
Imports: 53,818× 10^3 t <Remarks> Imports of coking coal: 53,818× 10^3 t Imports of PCI coal: 0	Imports: 53,818× 10^3 t [Imports of coking coal: 53,818× 10^3 t]

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.

<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.

Also, 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.

<Reference: Changes of crude oil stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 238.45× 10^3 kl	Stock changes: - 435× 10^3 t

<Explanation 2: Changes in NGL stock>

Stock changes concerning NGL were reported in the CRF. 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.

<Reference: Changes in NGL stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 18.72× 10^3 kl	Stock changes: 0

<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 figures for changes in gasoline stock reported in the CRF tables sometimes slightly differ from the figures in the IEA statistics, because the values relating to the supply and stock of oil in the IEA statistics refer to the values in the Monthly Oil Statistics of IEA, while those in the CRF tables refer to annual data.

<Reference: Changes in gasoline stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 165.67× 10^3 kl	Stock changes in motor gasoline: - 121× 10^3 t [- 164.39× 10^3 kl × 0.737 t/kl (density) = - 121.15× 10^3 t] <Reference>Stock changes in white spirit Stock changes in white spirit: - 1× 10^3 t [- 1.14× 10^3 kl × 0.737 t/kl (density) = - 1× 10^3 t]

<Explanation 4: Changes in jet kerosene stock>

The figures for changes in jet kerosene stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in jet kerosene stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 97.25× 10^3 kl	Stock changes: 76× 10^3 t [97.25× 10^3 kl × 0.7834 t/kl (density) = 76.18× 10^3 t]

<Explanation 5: Changes in kerosene stock>

The figures for changes in kerosene stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in kerosene stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 75.43× 10^3 kl	Stock changes: - 62× 10^3 t [- 75.43× 10^3 kl × 0.814 t/kl (density) = - 61.39× 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 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 while the IEA statistics did.

<Reference: Changes in gas/diesel oil stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 54.17× 10^3 kl	Stock changes: - 48× 10^3 t [- 54.17× 10^3 kl × 0.843 t/kl (density) = - 45.66× 10^3 t (stock changes in gas/diesel oil); - 2.20× 10^3 kl × 0.843 t/kl (density) = - 1.85× 10^3 t (stock changes in fuel oil A); - 45.66× 10^3 t - 1.85× 10^3 t = - 47.51× 10^3 t]

<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 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 29.20× 10^3 kl <Breakdown> Stock changes in fuel oil A: 2.20× 10^3 kl Stock changes in fuel oil C: - 31.40× 10^3 kl	Stock changes: 28× 10^3 t [31.40× 10^3 kl (stock changes in fuel oil C) × 0.900 t/kl (density) = 28.25× 10^3 t] <Remark> The figure of 26× 10^3 t in Energy Statistics of OECD Countries 2010-2011, 2013 Edition had turned out to be an error, thus the correction was reported to IEA.

<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 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 43.93× 10^3 t	Stock changes: 45× 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.

<Reference: Changes in naphtha stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 548.42× 10^3 kl	Stock changes: 404× 10^3 t [548.42× 10^3 kl × 0.737 t/kl (density) = 404.18× 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 other heavy oil and paraffin products. The IEA statistics reported figures for only asphalt under bitumen, and the figures for other heavy oil and paraffin 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 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 3.6× 10^3 t <Breakdown> Asphalt: 1.15× 10^3 t Other fuel oils and paraffin products: 2.45× 10^3 t	Stock changes in bitumen: - 1.15× 10^3 t <Remarks> In the IEA statistics, the figures for other heavy oil and paraffin products, which were reported under bitumen in the CRF tables, are reported under paraffin waxes.

<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 lubricating oil stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 59.90× 10^3 kl	Stock changes: 53.37× 10^3 t [59.90× 10^3 kl × 0.891 t/kl (density) = 53.37× 10^3 t]

<Explanation 12: Changes in oil coke stock>

The figures for changes in oil coke stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in oil coke stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: - 1.58× 10^3 t	Stock changes: 1.00× 10^3 t [11.25× 10^3 t (stocks at the end of March 2011) - 9.66× 10^3 t (stocks at the end of March 2012) = 1.59× 10^3 t] <Remarks> The above calculated value differs from the IEA published value, because when inputting on the IEA reporting file the stock changes (or the differences) are calculated after the stock amount at the end of each month is rounded off due to file formatting by the IEA.

<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 oil coke, and unlikely to be returned to oil refining processes. In addition, shipments of paraffin and oil coke produced using slack wax and slack coke were separately accounted for.

<Reference: Changes in refinery feedstock stock in 2011>

CRF Table 1.A(b)	IEA statistics
Stock changes: 62.63× 10^3 kl <Breakdown> Slack gasoline: 189.51× 10^3 kl Slack kerosene: - 104.84× 10^3 kl Slack diesel oil or gas oil: - 124.94× 10^3 kl Slack fuel oil: 102.91× 10^3 kl (Slack fuel oil is the aggregate of 123.77× 10^3 kl for slack fuel oil and - 20.86× 10^3 kl for slack lubricant)	Stock changes: - 25.00× 10^3 t <Breakdown> Slack gasoline: - 189.51× 10^3 kl Slack kerosene: 104.84× 10^3 kl Slack diesel oil or gas oil: 124.94× 10^3 kl Slack fuel oil: - 123.77× 10^3 kl Slack lubricant: 20.86× 10^3 kl Slack wax: 2.51× 10^3 kl Slack coke: 15.83× 10^3 kl Each of the above figures is multiplied by its density for conversion to weight for reporting purposes.
<Remarks> Other than the difference caused by slack wax and slack coke, the stock changes are different in some cases between the CRF tables and the IEA statistics because of the differences between monthly statistics and yearly statistics. The figures for the supply and stock of oil in the IEA statistics use the figures in the Monthly Oil Statistics compiled by the IEA. The report to the IEA for the MOS is submitted on a monthly basis. The monthly data may be adjusted for the yearly statistics. The CRF tables report annual data.	

<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 because of the differences in the methods used for estimation of changes in the imported LNG stock. Although the same figure for the domestic natural gas stock was reported in 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 2011>

CRF Table 1.A(b)	IEA statistics
Changes in LNG stock: - 4,208.33× 10^3 t Changes in domestic natural gas stock: - 8.35× 10^6 m^3	Stock changes: - 35.348 TJ (GCV) <Remarks> The figures for LNG and natural gas were combined under natural gas as the IEA statistics do not separate them.

A2.2. General Energy Statistics

A2.2.1. 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) [#1000], energy conversion (conversion) [#2000], and final energy consumption (final consumption) [#5000] — 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 are available on the following internet site:

http://www.enecho.meti.go.jp/info/statistics/jukyu/result-2.htm

The following is the energy balance simplified table (Table A 2-1 – Table A 2-6).

[1] Code number of the *General Energy Statistics* (Energy Balance Table)

Table A 2-1 Energy balance simplified table (General Energy Statistics, FY1990)

1990FY	Code	100	150	200	250	400	450	500	550	600	700	800		900	910	920
	<Energy balance simplified table>	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	New & Renewable Energy	Large-Scale Hydraulic	Nuclear Energy	Electricity	Heat		Total	Energy Total	Non-Energy Total
	<<Energy units>>	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ		TJ	TJ	TJ
Code																
1000	Primary Energy Supply	3,345,244	15,352	9,164,033	2,354,044	2,059,168	0	524,099	833,304	1,887,390	0	0		20,182,635	18,632,722	1,549,913
1100	Indigenous Production	187,036	0	24,484	0	89,203	0	524,099	833,304	1,887,390	0	0		3,545,517	0	0
1200	Import	3,158,208	15,352	9,139,549	2,354,044	1,969,965	0	0	0	0	0	0		16,637,118	0	0
1500	Total Primary Energy Supply	3,345,244	15,352	9,164,033	2,354,044	2,059,168	0	524,099	833,304	1,887,390	0	0		20,182,635	18,632,722	1,549,913
1600	Export	-53	-56,644	0	-302,130	0	0	0	0	0	0	0		-358,828	0	
1700	Stockpile Change	1,669	1,951	-190,171	-22,710	42,651	0	0	0	0	0	0		-166,610	0	0
1900	Domestic Primary Energy Supply	3,346,859	-39,341	8,973,862	2,029,203	2,101,819	0	524,099	833,304	1,887,390	0	0	supply side	19,657,197	18,107,284	1,549,913
													consumption side	19,785,779	18,235,866	1,549,913
2000	Energy Transformation & Own use	-3,039,243	1,595,040	-9,032,036	5,785,908	-2,039,503	629,852	-470,769	-833,304	-1,887,390	2,698,536	696,058		-5,896,853	-5,865,031	-31,822
2100	Power Genertion	-673,045	-204,274	-874,209	-1,055,765	-1,531,630	0	-19,259	-767,173	-1,879,280	2,691,329	0		-4,313,307	-4,313,307	0
2200	Auto Power Generation	-116,820	-96,004	0	-399,646	-5,054	-12,280	-170,874	-66,131	-8,110	304,022	0		-570,897	-570,897	0
2300	Industrial Steam Generation	-123,177	-69,991	0	-444,065	-2,693	-15,028	-278,052	0	0	0	784,558		-148,448	-148,448	0
2350	District Heat Supply	-824	0	0	-2,633	0	-6,169	-2,028	0	0	-1,229	8,464		-4,419	-4,419	0
2400	Town Gas Production	0	-19,178	0	-142,210	-503,865	664,661	-546	0	0	0	0		-1,139	-1,139	0
2500	Coal Products	-2,142,396	2,081,208	0	-38,206	0	0	0	0	0	0	0		-99,394	-99,394	0
2600	Oil Products	0	0	-8,143,167	8,175,984	5,121	0	0	0	0	0	-94,149		-56,212	0	-56,212
2700	Other Conversions & Blending	30,171	2,880	0	-18,897	0	18,897	0	0	0	0	0		33,051	0	33,051
2800	Total Conversion	-3,026,090	1,694,639	-9,017,376	6,074,562	-2,038,122	650,081	-470,758	-833,304	-1,887,390	2,994,122	698,872		-5,160,764	-5,137,603	-23,161
2900	Own Use & Loss	-3,015	-101,777	-1,017	-301,251	-1,738	-20,230	0	0	0	-295,586	-2,814		-727,428	-727,428	0
3000	Other Imput/Output	0	0	0	12,924	0	0	0	0	0	0	0		12,924	0	12,924
3500	Stock Change	-10,138	2,177	-13,642	-327	357	0	-10	0	0	0	0		-21,584	0	-21,584
4000	Stastical Discrepancy	-75,007	0	-58,202	3,856	769	0	0	0	0	2	0		-128,582	-128,582	0
5000	Final Energy Consumption	382,623	1,555,699	28	7,811,256	61,547	629,852	53,330	0	0	2,698,534	696,058		13,888,926	12,370,836	1,518,091
6000	Industry	365,162	1,532,019	28	3,019,423	57,690	110,593	0	0	0	1,220,265	687,697		6,992,876	5,516,717	1,476,159
6100	Non-Manufacturing	263	1,141	28	759,211	3,757	20,677	0	0	0	21,251	0		806,329	553,571	252,758
6500	Manufacturing	364,899	1,530,877	0	2,260,212	53,933	89,916	0	0	0	1,199,013	687,697		6,186,547	4,963,145	1,223,401
6520	Pulp & Paper	126	0	0	27,726	2	1,272	0	0	0	121,360	249,523		400,009	400,009	0
6550	Chemical	5,443	46,803	0	1,356,286	26,599	1,028	0	0	0	186,050	185,545		1,807,754	670,574	1,137,180
6570	Cement & Ceramics	235,223	40,381	0	104,386	20	743	0	0	0	79,708	6,706		467,168	456,544	10,624
6580	Iron & Steel	143,931	1,103,634	0	119,268	25,030	8,746	0	0	0	265,486	92,916		1,759,011	1,758,326	685
6600	Machinery	15	16,700	0	85,879	2,132	22,135	0	0	0	212,915	0		339,776	339,776	0
6700	Duplication Adjustment	-36,513	-8,421	0	-56,803	-3,000	-2,137	0	0	0	-49,573	-22,295		-178,742	-169,225	-9,517
6900	Other Industries & SMEs	1,164	320,931	0	354,525	2,014	31,396	0	0	0	235,503	121,650		1,067,184	982,755	84,429
7000	ResCom	17,428	23,680	0	1,634,972	3,857	519,255	53,330	0	0	1,417,755	8,361		3,678,640	3,677,460	1,180
7100	Residential	0	2,880	0	594,332	0	342,157	51,488	0	0	662,933	1,284		1,655,075	1,655,075	0
7150	HokkaidoTohoku,Hokuriku	0	0	0	214,484	0	41,416	0	0	0	104,048	0		359,948	359,948	0
7160	Kantou, Toukai, Kansai	0	0	0	285,397	0	337,114	0	0	0	416,516	0		1,039,026	1,039,026	0
7170	Chuugoku,Shikoku,Kyushu,Okinawa	0	0	0	119,753	0	48,044	0	0	0	143,216	0		311,012	311,012	0
7500	Commercial & Others	17,428	20,801	0	1,040,640	3,857	177,098	1,842	0	0	754,822	7,077		2,023,565	2,022,385	1,180
7510	Water supply, Sewage & Waste Disposal	262	0	0	73,615	0	3,295	0	0	0	67,696	4		144,872	144,872	0
7540	Telecommunication & Broadcasting	0	0	0	9,009	0	2,257	0	0	0	19,005	395		30,666	30,666	0
7600	Trade & Finance Service	0	0	0	259,263	0	25,973	0	0	0	188,251	2,656		476,143	476,143	0
7700	Public Service	12,038	0	0	274,167	0	49,255	0	0	0	214,702	1,346		551,508	551,508	0
7810	Commercial Service	235	261	0	97,285	0	4,358	0	0	0	55,712	413		158,265	158,265	0
7850	Retail Service	2,406	1,906	0	219,818	0	67,360	0	0	0	135,481	1,576		428,547	428,547	0
8000	Transportation	33	0	0	3,156,861	0	3	0	0	0	60,514	0		3,217,411	3,176,659	40,752
8100	Passenger	33	0	0	1,614,051	0	1	0	0	0	56,610	0		1,670,694	1,638,892	31,802
8110	Car	0	0	0	1,375,786	0	1	0	0	0	0	0		1,375,787	1,344,141	31,646
8120	Rail	33	0	0	11,264	0	0	0	0	0	56,610	0		67,907	67,750	156
8130	Ship	0	0	0	67,628	0	0	0	0	0	0	0		67,628	67,628	0
8140	Air	0	0	0	88,429	0	0	0	0	0	0	0		88,429	88,429	0
8500	Freight	0	0	0	1,542,810	0	3	0	0	0	3,905	0		1,546,717	1,537,767	8,950
8510	Truck & Lorry	0	0	0	1,391,105	0	3	0	0	0	0	0		1,391,107	1,386,475	4,632
8520	Rail	0	0	0	2,638	0	0	0	0	0	3,905	0		6,543	6,374	169
8530	Ship	0	0	0	130,812	0	0	0	0	0	0	0		130,812	126,662	4,149
8540	Air	0	0	0	18,256	0	0	0	0	0	0	0		18,256	18,256	0
9000	Final Energy Consumption	382,112	1,538,556	28	6,324,859	47,544	629,814	53,330	0	0	2,698,534	696,058		12,370,836	12,370,836	0
9500	Non-Energy	511	17,143	0	1,486,397	14,003	38	0	0	0	0	0		1,518,091	0	1,518,091
9600	Industry	511	17,143	0	1,444,465	14,003	38	0	0	0	0	0		1,476,159	0	1,476,159
9800	ResCom & others	0	0	0	1,180	0	0	0	0	0	0	0		1,180	0	1,180
9850	Transport	0	0	0	40,752	0	0	0	0	0	0	0		40,752	0	40,752

Table A 2-2 Energy balance simplified table (General Energy Statistics, FY1995)

1995FY	Code	100	150	200	250	400	450	500	550	600	700	800		900	910	920
<Energy balance simplified table>		Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	New & Renewable Energy	Large-Scale Hydraulic	Nuclear Energy	Electricity	Heat		Total	Energy Total	Non-Energy Total
<<Energy units>>		TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ		TJ	TJ	TJ
Code																
1000	Primary Energy Supply	3,732,254	18,016	10,204,290	2,225,292	2,479,453	0	564,207	761,329	2,700,257	0	0		22,685,097	20,955,245	1,729,852
1100	Indigenous Production	149,495	0	32,455	0	95,250	0	564,207	761,329	2,700,257	0	0		4,302,993	0	0
1200	Import	3,582,759	18,016	10,171,835	2,225,292	2,384,203	0	0	0	0	0	0		18,382,105	0	0
1500	Total Primary Energy Supply	3,732,254	18,016	10,204,290	2,225,292	2,479,453	0	564,207	761,329	2,700,257	0	0		22,685,097	20,955,245	1,729,852
1600	Export	-75	-103,811	0	-733,696	0	0	0	0	0	0	0		-837,582	0	
1700	Stockpile Change	-2,710	-6,113	-30,486	134,344	58,576	0	0	0	0	0	0		153,611	0	0
1900	Domestic Primary Energy Supply	3,729,468	-91,908	10,173,804	1,625,939	2,538,029	0	564,207	761,329	2,700,257	0	0	supply side	22,001,126	20,271,274	1,729,852
													consumption side	21,947,773	20,217,921	1,729,852
2000	Energy Transformation & Own use	-3,286,798	1,395,073	-10,108,952	7,217,919	-2,474,669	823,061	-518,878	-761,329	-2,700,257	3,090,955	694,292		-6,629,583	-6,626,513	-3,070
2100	Power Genertion	-1,072,304	-210,723	-669,401	-838,649	-1,750,818	0	-36,870	-700,065	-2,687,729	3,071,160	0		-4,895,399	-4,895,399	0
2200	Auto Power Generation	-150,687	-115,758	-880	-459,430	-5,691	-32,050	-199,357	-61,264	-12,528	364,710	0		-672,935	-672,935	0
2300	Industrial Steam Generation	-133,278	-60,234	-328	-446,810	-2,879	-30,180	-278,056	0	0	0	784,719		-167,044	-167,044	0
2350	District Heat Supply	-638	0	0	-1,638	0	-11,101	-4,577	0	0	-2,548	16,423		-4,079	-4,079	0
2400	Town Gas Production	0	-12,205	0	-157,821	-723,643	892,307	-37	0	0	0	0		-1,400	-1,400	0
2500	Coal Products	-1,963,775	1,893,360	0	-30,083	0	0	0	0	0	0	0		-100,498	-100,498	0
2600	Oil Products	0	0	-9,421,404	9,490,043	5,773	0	0	0	0	0	-103,260		-28,847	-0	-28,847
2700	Other Conversions & Blending	36,411	1,637	0	-22,539	0	22,539	0	0	0	0	0		38,047	0	38,047
2800	Total Conversion	-3,284,272	1,496,077	-10,092,012	7,533,073	-2,477,258	841,515	-518,897	-761,329	-2,700,257	3,433,322	697,882		-5,832,154	-5,841,355	9,200
2900	Own Use & Loss	-2,978	-93,780	-1,058	-321,669	-1,261	-18,454	0	0	0	-342,367	-3,590		-785,158	-785,158	0
3000	Other Imput/Output	0	0	0	9,078	0	0	0	0	0	0	0		9,078	0	9,078
3500	Stock Change	452	-7,224	-15,882	-2,563	3,850	0	19	0	0	0	0		-21,348	0	-21,348
4000	Stastical Discrepancy	-7,652	0	64,852	-8,469	4,622	0	-0	0	0	0	0		53,353	53,353	0
5000	Final Energy Consumption	450,322	1,303,165	0	8,852,328	58,738	823,061	45,329	0	0	3,090,955	694,292		15,318,190	13,591,408	1,726,782
6000	Industry	428,876	1,299,570	0	3,267,149	56,329	163,883	36	0	0	1,269,782	678,469		7,164,096	5,471,642	1,692,454
6100	Non-Manufacturing	191	528	0	735,650	1,776	26,151	0	0	0	20,464	0		784,760	557,911	226,848
6500	Manufacturing	428,685	1,299,042	0	2,531,499	54,553	137,733	36	0	0	1,249,318	678,469		6,379,336	4,913,731	1,465,605
6520	Pulp & Paper	0	0	0	30,072	5	5,747	36	0	0	126,598	246,261		408,718	408,718	0
6550	Chemical	6,176	34,647	0	1,705,864	21,627	6,650	0	0	0	199,040	193,896		2,167,901	799,104	1,368,797
6570	Cement & Ceramics	235,274	37,704	0	118,517	341	628	0	0	0	84,884	8,266		485,615	475,539	10,076
6580	Iron & Steel	201,778	958,301	0	114,033	26,245	20,866	0	0	0	255,475	94,083		1,670,781	1,670,574	208
6600	Machinery	4	14,083	0	89,461	3,476	32,517	0	0	0	236,790	0		376,331	376,331	0
6700	Duplication Adjustment	-26,421	-5,593	0	-81,902	-1,529	-3,384	0	0	0	-49,200	-20,224		-188,251	-182,224	-6,028
6900	Other Industries & SMEs	1,841	250,502	0	261,747	2,608	40,947	0	0	0	244,492	104,443		906,581	814,028	92,553
7000	ResCom	21,415	3,594	0	1,846,240	2,409	659,036	45,293	0	0	1,753,655	15,823		4,347,465	4,345,637	1,828
7100	Residential	0	1,637	0	700,079	0	398,516	43,786	0	0	827,334	1,368		1,972,720	1,972,720	0
7150	HokkaidoTohoku,Hokuriku	0	0	0	245,943	0	46,561	0	0	0	135,963	0		428,467	428,467	0
7160	Kantou, Toukai, Kansai	0	0	0	330,756	0	367,163	0	0	0	541,005	0		1,238,924	1,238,924	0
7170	Chuugoku,Shikoku,Kyushu,Okinawa	0	0	0	145,241	0	50,323	0	0	0	187,224	0		382,789	382,789	0
7500	Commercial & Others	21,415	1,958	0	1,146,160	2,409	260,521	1,507	0	0	926,321	14,455		2,374,746	2,372,918	1,828
7510	Water supply, Sewage & Waste Disposal	426	0	0	113,365	0	4,750	0	0	0	63,661	8		182,210	182,210	0
7540	Telecommunication & Broadcasting	0	0	0	10,732	0	2,438	0	0	0	22,209	384		35,764	35,764	0
7600	Trade & Finance Service	0	0	0	269,831	0	40,343	0	0	0	201,589	6,828		518,593	518,593	0
7700	Public Service	16,599	0	0	364,499	0	75,063	0	0	0	277,487	1,960		735,608	735,608	0
7810	Commercial Service	330	254	0	98,680	0	5,580	0	0	0	66,005	587		171,435	171,435	0
7850	Retail Service	3,820	1,682	0	261,577	0	154,955	0	0	0	160,825	3,268		586,127	586,127	0
8000	Transportation	31	0	0	3,738,939	0	141	0	0	0	67,518	0		3,806,629	3,774,129	32,500
8100	Passenger	31	0	0	2,044,897	0	20	0	0	0	63,676	0		2,108,624	2,083,737	24,887
8110	Car	0	0	0	1,787,686	0	1	0	0	0	0	0		1,787,687	1,762,916	24,771
8120	Rail	31	0	0	9,759	0	0	0	0	0	63,676	0		73,466	73,350	116
8130	Ship	0	0	0	79,258	0	0	0	0	0	0	0		79,258	79,258	0
8140	Air	0	0	0	128,698	0	0	0	0	0	0	0		128,698	128,698	0
8500	Freight	0	0	0	1,694,042	0	121	0	0	0	3,842	0		1,698,005	1,690,392	7,613
8510	Truck & Lorry	0	0	0	1,566,432	0	121	0	0	0	0	0		1,566,553	1,562,573	3,980
8520	Rail	0	0	0	2,400	0	0	0	0	0	3,842	0		6,242	6,130	112
8530	Ship	0	0	0	131,840	0	0	0	0	0	0	0		131,840	128,319	3,521
8540	Air	0	0	0	24,397	0	0	0	0	0	0	0		24,397	24,397	0
9000	Final Energy Consumption	449,885	1,291,322	0	7,149,862	46,702	823,061	45,329	0	0	3,090,955	694,292		13,591,408	13,591,408	0
9500	Non-Energy	437	11,843	0	1,702,466	12,036	0	0	0	0	0	0		1,726,782	0	1,726,782
9600	Industry	437	11,843	0	1,668,138	12,036	0	0	0	0	0	0		1,692,454	0	1,692,454
9800	ResCom & others	0	0	0	1,828	0	0	0	0	0	0	0		1,828	0	1,828
9850	Transport	0	0	0	32,500	0	0	0	0	0	0	0		32,500	0	32,500

Table A 2-3 Energy balance simplified table (General Energy Statistics, FY2000)

2000FY Code		100	150	200	250	400	450	500	550	600	700	800		900	910	920
	<Energy balance simplified table>	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	New & Renewable Energy	Large-Scale Hydraulic	Nuclear Energy	Electricity	Heat		Total	Energy Total	Non-Energy Total
	<<Energy units>>	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ		TJ	TJ	TJ
Code																
1000	Primary Energy Supply	4,210,040	76,219	9,761,365	2,246,246	3,060,666	0	616,335	778,417	2,873,130	0	0		23,622,418	21,719,570	1,902,848
1100	Indigenous Production	66,013	0	28,034	0	106,340	0	616,335	778,417	2,873,130	0	0		4,468,269	0	0
1200	Import	4,144,027	76,219	9,733,330	2,246,246	2,954,327	0	0	0	0	0	0		19,154,149	0	0
1500	Total Primary Energy Supply	4,210,040	76,219	9,761,365	2,246,246	3,060,666	0	616,335	778,417	2,873,130	0	0		23,622,418	21,719,570	1,902,848
1600	Export	-112	-78,077	0	-627,862	0	0	0	0	0	0	0		-706,051	0	
1700	Stockpile Change	-2,958	-1,963	-116,285	-106,335	72,387	0	0	0	0	0	0		-155,155	0	0
1900	Domestic Primary Energy Supply	4,206,970	-3,821	9,645,079	1,512,049	3,133,054	0	616,335	778,417	2,873,130	0	0	supply side	22,761,213	20,858,365	1,902,848
													consumption side	22,790,985	20,888,136	1,902,848
2000	Energy Transformation & Own use	-3,736,666	1,287,540	-9,721,175	7,518,258	-3,072,804	986,782	-562,115	-778,417	-2,873,130	3,396,151	739,685		-6,815,890	-6,685,083	-130,807
2100	Power Genertion	-1,515,218	-212,244	-301,245	-548,677	-2,131,677	-1,447	-46,226	-711,603	-2,866,777	3,333,294	0		-5,001,815	-5,001,815	0
2200	Auto Power Generation	-199,734	-148,205	-99	-425,144	-9,644	-38,900	-211,258	-66,814	-6,353	423,092	0		-683,058	-683,058	0
2300	Industrial Steam Generation	-191,460	-34,306	-119	-428,955	-6,984	-30,434	-298,304	0	0	0	857,666		-132,897	-132,897	0
2350	District Heat Supply	-708	0	0	-1,725	0	-14,515	-6,275	0	0	-3,940	23,428		-3,735	-3,735	0
2400	Town Gas Production	0	-9,573	0	-126,581	-925,315	1,061,122	-31	0	0	0	0		-377	-377	0
2500	Coal Products	-1,816,696	1,790,538	0	-39,481	0	0	0	0	0	0	0		-65,640	-65,640	0
2600	Oil Products	0	0	-9,431,042	9,467,009	6,972	0	0	0	0	0	-137,327		-94,389	0	-94,389
2700	Other Conversions & Blending	17,846	0	0	-23,232	0	23,232	0	0	0	0	0		17,846	0	17,846
2800	Total Conversion	-3,705,970	1,386,210	-9,732,505	7,873,214	-3,066,643	999,058	-562,094	-778,417	-2,873,130	3,752,445	743,767		-5,964,065	-5,887,523	-76,543
2900	Own Use & Loss	-4,240	-93,659	-518	-325,749	-743	-12,276	0	0	0	-356,294	-4,082		-797,561	-797,561	0
3000	Other Imput/Output	0	0	0	-32,610	0	0	0	0	0	0	0		-32,610	0	-32,610
3500	Stock Change	-26,456	-5,012	11,849	3,404	-5,418	0	-21	0	0	0	0		-21,654	0	-21,654
4000	Stastical Discrepancy	43,208	0	-76,095	-6,521	9,637	0	0	0	0	0	0		-29,772	-29,772	0
5000	Final Energy Consumption	427,096	1,283,719	0	9,036,828	50,613	986,782	54,220	0	0	3,396,151	739,685		15,975,094	14,203,053	1,772,041
6000	Industry	402,587	1,281,740	0	3,284,658	49,960	159,109	18,388	0	0	1,307,620	717,036		7,221,098	5,490,897	1,730,201
6100	Non-Manufacturing	178	603	0	608,480	1,930	25,527	0	0	0	17,223	0		653,942	474,431	179,511
6500	Manufacturing	402,409	1,281,136	0	2,676,177	48,030	133,583	18,388	0	0	1,290,397	717,036		6,567,156	5,016,466	1,550,690
6520	Pulp & Paper	0	0	0	20,792	70	563	12,142	0	0	132,838	253,277		419,682	419,682	0
6550	Chemical	19	37,438	0	1,809,648	23,095	3,181	0	0	0	179,582	256,781		2,309,744	843,806	1,465,939
6570	Cement & Ceramics	184,710	23,143	0	85,120	175	489	6,235	0	0	79,974	10,800		390,646	390,154	492
6580	Iron & Steel	223,836	977,757	0	100,256	22,175	31,628	0	0	0	253,494	105,469		1,714,614	1,714,463	152
6600	Machinery	0	6,359	0	37,273	945	18,502	2	0	0	262,650	0		325,731	325,731	0
6700	Duplication Adjustment	-12,253	-1,231	0	-27,736	-176	-676	-10	0	0	-40,768	-88,966		-171,817	-171,817	-0
6900	Other Industries & SMEs	1,927	227,946	0	423,747	0	46,382	0	0	0	266,689	124,234		1,090,926	1,006,819	84,107
7000	ResCom	24,463	1,979	0	1,891,287	653	826,532	35,833	0	0	2,021,667	22,648		4,825,062	4,817,384	7,678
7100	Residential	0	0	0	731,171	0	418,454	34,912	0	0	928,274	1,306		2,114,117	2,114,117	0
7150	HokkaidoTohoku,Hokuriku	0	0	0	258,987	0	52,403	0	0	0	166,607	0		477,997	477,997	0
7160	Kantou, Toukai, Kansai	0	0	0	339,898	0	417,463	0	0	0	624,718	0		1,382,078	1,382,078	0
7170	Chugoku,Shikoku,Kyushu,Okinawa	0	0	0	147,430	0	50,550	0	0	0	210,400	0		408,379	408,379	0
7500	Commercial & Others	24,463	1,979	0	1,160,116	653	408,078	921	0	0	1,093,394	21,342		2,710,946	2,703,268	7,678
7510	Water supply, Sewage & Waste Disposal	521	0	0	100,189	0	7,316	0	0	0	76,046	12		184,085	184,085	0
7540	Telecommunication & Broadcasting	0	0	0	18,618	0	5,698	0	0	0	36,920	605		61,841	61,841	0
7600	Trade & Finance Service	0	0	0	258,854	0	54,325	0	0	0	230,281	9,039		552,499	552,499	0
7700	Public Service	17,507	0	0	419,901	0	124,201	0	0	0	363,562	3,024		928,195	928,195	0
7810	Commercial Service	464	334	0	106,094	0	8,911	0	0	0	88,762	1,066		205,631	205,631	0
7850	Retail Service	4,658	1,567	0	280,109	0	205,098	0	0	0	196,235	4,745		692,411	692,411	0
8000	Transportation	46	0	0	3,860,884	0	1,141	0	0	0	66,864	0		3,928,934	3,894,772	34,162
8100	Passenger	46	0	0	2,283,876	0	172	0	0	0	63,385	0		2,347,478	2,321,731	25,746
8110	Car	0	0	0	2,086,803	0	20	0	0	0	0	0		2,086,823	2,061,171	25,652
8120	Rail	46	0	0	8,598	0	0	0	0	0	63,385	0		72,028	71,934	94
8130	Ship	0	0	0	78,498	0	0	0	0	0	0	0		78,498	78,498	0
8140	Air	0	0	0	134,790	0	0	0	0	0	0	0		134,790	134,790	0
8500	Freight	0	0	0	1,577,008	0	969	0	0	0	3,479	0		1,581,456	1,573,040	8,416
8510	Truck & Lorry	0	0	0	1,558,126	0	969	0	0	0	0	0		1,559,096	1,556,485	2,610
8520	Rail	0	0	0	1,878	0	0	0	0	0	3,479	0		5,357	5,274	83
8530	Ship	0	0	0	137,346	0	0	0	0	0	0	0		137,346	131,623	5,722
8540	Air	0	0	0	24,246	0	0	0	0	0	0	0		24,246	24,246	0
9000	Final Energy Consumption	427,096	1,268,259	0	7,288,772	42,088	986,782	54,220	0	0	3,396,151	739,685		14,203,053	14,203,053	0
9500	Non-Energy	0	15,460	0	1,748,057	8,525	0	0	0	0	0	0		1,772,041	0	1,772,041
9600	Industry	0	15,460	0	1,706,216	8,525	0	0	0	0	0	0		1,730,201	0	1,730,201
9800	ResCom & others	0	0	0	7,678	0	0	0	0	0	0	0		7,678	0	7,678
9850	Transport	0	0	0	34,162	0	0	0	0	0	0	0		34,162	0	34,162

Table A 2-4 Energy balance simplified table (General Energy Statistics, FY2005)

2005FY Code	100	150	200	250	400	450	500	550	600	700	800		900	910	920
<Energy balance simplified table>	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	New & Renewable Energy	Large-Scale Hydraulic	Nuclear Energy	Electricity	Heat		Total	Energy Total	Non-Energy Total
<<Energy units>>	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ		TJ	TJ	TJ
Code															
1000 Primary Energy Supply	4,747,650	81,314	9,506,203	2,135,196	3,288,496	0	676,445	671,713	2,676,958	0	0		23,783,976	21,767,430	2,016,545
1100 Indigenous Production	0	0	33,051	0	134,612	0	676,445	671,713	2,676,958	0	0		4,192,778	0	0
1200 Import	4,747,650	81,314	9,473,152	2,135,196	3,153,885	0	0	0	0	0	0		19,591,198	0	0
1500 Total Primary Energy Supply	4,747,650	81,314	9,506,203	2,135,196	3,288,496	0	676,445	671,713	2,676,958	0	0		23,783,976	21,767,430	2,016,545
1600 Export	-85	-49,279	0	-897,381	0	0	0	0	0	0	0		-946,745	0	
1700 Stockpile Change	0	-16,228	-96,075	-73,435	105,352	0	0	0	0	0	0		-80,386	0	0
1900 Domestic Primary Energy Supply	4,747,565	15,807	9,410,128	1,164,381	3,393,848	0	676,445	671,713	2,676,958	0	0	supply side	22,756,844	20,740,299	2,016,545
												consumption side	23,025,349	21,001,487	2,016,545
2000 Energy Transformation & Own use	-4,380,236	1,328,905	-9,637,342	7,534,806	-3,318,058	1,206,465	-645,344	-671,713	-2,676,958	3,515,694	714,918		-7,028,862	-6,832,682	-188,862
2100 Power Generation	-2,146,038	-186,507	-301,537	-546,923	-1,912,210	-58,869	-76,110	-613,992	-2,676,958	3,440,416	0		-5,071,412	-5,071,412	0
2200 Auto Power Generation	-225,239	-138,544	-24	-396,248	-18,506	-67,598	-247,349	-57,720	0	464,983	0		-686,246	-686,246	0
2300 Industrial Steam Generation	-201,817	-33,452	-33	-364,073	-10,580	-53,178	-314,989	0	0	0	832,833		-145,289	-145,289	0
2350 District Heat Supply	-633	0	0	-1,058	0	-18,102	-6,739	0	0	-4,129	25,984		-4,677	-4,677	0
2400 Town Gas Production	0	-1,994	0	-76,818	-1,315,225	1,391,962	-46	0	0	0	0		-2,121	-2,121	0
2500 Coal Products	-1,852,761	1,802,622	0	-19,827	0	0	0	0	0	0	0		-69,966	-69,966	0
2600 Oil Products	0	0	-9,331,018	9,324,886	8,203	0	0	0	0	0	-139,784		-137,714	0	-137,714
2700 Other Conversions & Blending	18,933	0	0	-22,505	0	22,505	0	0	0	0	0		18,933	0	18,933
2800 Total Conversion	-4,407,555	1,442,124	-9,632,613	7,897,434	-3,248,318	1,216,719	-645,232	-671,713	-2,676,958	3,901,270	719,033		-6,105,809	-5,979,711	-118,781
2900 Own Use & Loss	-6,994	-94,841	-85	-309,370	-41,736	-10,254	0	0	0	-385,576	-4,115		-852,972	-852,972	0
3000 Other Imput/Output	0	0	0	-53,184	0	0	0	0	0	0	0		-53,184	0	-53,184
3500 Stock Change	34,314	-18,378	-4,644	-73	-28,004	0	-112	0	0	0	0		-16,897	0	-16,897
4000 Stastical Discrepancy	-48,131	0	-227,214	-2,538	9,378	0	-0	0	0	0	0		-268,505	-261,187	0
5000 Final Energy Consumption	415,460	1,344,712	0	8,701,725	66,413	1,206,465	31,100	0	0	3,515,694	714,918		15,996,487	14,168,804	1,827,683
6000 Industry	394,168	1,342,658	0	3,142,673	65,661	191,539	6,329	0	0	1,231,595	689,846		7,064,470	5,273,144	1,791,326
6100 Non-Manufacturing	100	191	0	503,751	2,758	30,491	0	0	0	10,887	0		548,178	423,510	124,667
6500 Manufacturing	394,067	1,342,467	0	2,638,922	62,903	161,049	6,329	0	0	1,220,708	689,846		6,516,292	4,849,634	1,666,658
6520 Pulp & Paper	0	0	0	18,699	119	762	25	0	0	127,812	242,031		389,447	389,447	0
6550 Chemical	4,351	37,042	0	1,880,133	31,475	5,702	0	0	0	171,601	242,225		2,372,528	789,974	1,582,554
6570 Cement & Ceramics	161,134	20,463	0	75,555	185	842	6,300	0	0	78,074	9,075		351,627	348,954	2,673
6580 Iron & Steel	248,848	971,128	0	84,755	25,945	47,754	0	0	0	253,662	97,734		1,729,825	1,729,695	130
6600 Machinery	1	5,255	0	36,649	3,007	25,317	5	0	0	285,518	0		355,752	355,752	0
6700 Duplication Adjustment	-24,479	0	0	-20,151	-500	-754	0	0	0	-33,744	-77,425		-157,052	-154,564	-2,488
6900 Other Industries & SMEs	1,409	299,506	0	386,675	0	28,603	0	0	0	191,277	129,120		1,036,590	952,801	83,789
7000 ResCom	21,255	2,054	0	1,872,067	751	1,010,951	24,771	0	0	2,215,492	25,072		5,172,413	5,170,218	2,195
7100 Residential	0	0	0	701,600	0	435,817	24,018	0	0	1,019,088	1,326		2,181,848	2,181,848	0
7150 HokkaidoTohoku,Hokuriku	0	0	0	252,024	0	57,970	0	0	0	182,318	0		492,311	492,311	0
7160 Kantou, Toukai, Kansai	0	0	0	329,849	0	472,168	0	0	0	705,199	0		1,507,215	1,507,215	0
7170 Chugoku,Shikoku,Kyushu,Okinawa	0	0	0	151,797	0	55,495	0	0	0	243,104	0		450,396	450,396	0
7500 Commercial & Others	21,255	2,054	0	1,170,467	751	575,134	753	0	0	1,196,404	23,746		2,990,565	2,988,370	2,195
7510 Water supply, Sewage & Waste Disposal	707	0	0	97,018	0	10,275	0	0	0	77,680	10		185,689	185,689	0
7540 Telecommunication & Broadcasting	0	0	0	16,400	0	7,767	0	0	0	33,240	687		58,094	58,094	0
7600 Trade & Finance Service	0	0	0	228,066	0	184,556	0	0	0	369,264	7,442		789,329	789,329	0
7700 Public Service	15,580	0	0	396,400	0	165,795	0	0	0	345,691	2,515		925,981	925,981	0
7810 Commercial Service	785	220	0	83,668	0	8,214	0	0	0	87,825	947		181,659	181,659	0
7850 Retail Service	2,159	1,798	0	264,254	0	238,811	0	0	0	193,168	2,954		703,145	703,145	0
8000 Transportation	37	0	0	3,686,985	0	3,974	0	0	0	68,607	0		3,759,604	3,725,441	34,162
8100 Passenger	37	0	0	2,242,955	0	591	0	0	0	65,029	0		2,308,612	2,282,866	25,746
8110 Car	0	0	0	1,968,839	0	68	0	0	0	0	0		1,968,907	1,943,255	25,652
8120 Rail	37	0	0	7,833	0	0	0	0	0	65,029	0		72,899	72,805	94
8130 Ship	0	0	0	70,204	0	0	0	0	0	0	0		70,204	70,204	0
8140 Air	0	0	0	137,208	0	0	0	0	0	0	0		137,208	137,208	0
8500 Freight	0	0	0	1,444,030	0	3,383	0	0	0	3,578	0		1,450,992	1,442,575	8,417
8510 Truck & Lorry	0	0	0	1,333,297	0	3,383	0	0	0	0	0		1,336,680	1,334,070	2,610
8520 Rail	0	0	0	1,718	0	0	0	0	0	3,578	0		5,296	5,212	84
8530 Ship	0	0	0	117,819	0	0	0	0	0	0	0		117,819	112,097	5,722
8540 Air	0	0	0	23,641	0	0	0	0	0	0	0		23,641	23,641	0
9000 Final Energy Consumption	415,460	1,329,123	0	6,905,897	50,146	1,206,465	31,100	0	0	3,515,694	714,918		14,168,804	14,168,804	0
9500 Non-Energy	0	15,589	0	1,795,828	16,266	0	0	0	0	0	0		1,827,683	0	1,827,683
9600 Industry	0	15,589	0	1,759,470	16,266	0	0	0	0	0	0		1,791,326	0	1,791,326
9800 ResCom & others	0	0	0	2,195	0	0	0	0	0	0	0		2,195	0	2,195
9850 Transport	0	0	0	34,162	0	0	0	0	0	0	0		34,162	0	34,162

Table A 2-5 Energy balance simplified table (General Energy Statistics, FY2010)

2010FY	Code	100	150	200	250	400	450	500	550	600	700	800		900	910	920
	<Energy balance simplified table>	Coal	Coal Products	Oil	Oil Products	Natural Gas	Town Gas	New & Renewable Energy	Large-Scale Hydraulic	Nuclear Energy	Electricity	Heat		Total	Energy Total	Non-Energy Total
	<<Energy units>>	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ	TJ		TJ	TJ	TJ
Code																
1000	Primary Energy Supply	4,967,481	29,909	8,169,936	1,931,450	4,001,721	0	790,218	711,607	2,494,879	0	0		23,097,201	21,328,540	1,768,661
1100	Indigenous Production	0	0	30,637	0	149,324	0	790,218	711,607	2,494,879	0	0		4,176,666	0	0
1200	Import	4,967,481	29,909	8,139,299	1,931,450	3,852,397	0	0	0	0	0	0		18,920,536	0	0
1500	Total Primary Energy Supply	4,967,481	29,909	8,169,936	1,931,450	4,001,721	0	790,218	711,607	2,494,879	0	0		23,097,201	21,328,540	1,768,661
1600	Export	-87	-19,695	0	-1,208,645	0	0	0	0	0	0	0		-1,228,427	0	
1700	Stockpile Change	0	3,901	-35,331	-28,524	230,394	0	0	0	0	0	0		170,441	0	0
1900	Domestic Primary Energy Supply	4,967,395	14,115	8,134,605	694,281	4,232,115	0	790,218	711,607	2,494,879	0	0	supply side	22,039,215	20,270,554	1,768,661
													consumption side	21,837,614	20,064,922	1,768,661
2000	Energy Transformation & Own use	-4,379,065	1,324,844	-8,108,439	6,767,389	-4,181,580	1,450,558	-764,504	-711,607	-2,494,879	3,585,621	646,677		-6,864,986	-6,834,051	-26,903
2100	Power Genertion	-2,084,699	-200,982	-189,297	-374,299	-2,347,369	-59,859	-89,271	-568,728	-2,494,879	3,474,135	0		-4,931,217	-4,931,217	0
2200	Auto Power Generation	-229,502	-131,191	-59	-273,973	-31,595	-72,007	-322,094	-142,879	0	498,712	0		-704,589	-704,589	0
2300	Industrial Steam Generation	-209,762	-37,780	-77	-255,637	-22,806	-66,125	-346,781	0	0	0	773,961		-165,007	-165,007	0
2350	District Heat Supply	0	0	0	-841	0	-17,003	-5,562	0	0	-4,126	25,462		-2,070	-2,070	0
2400	Town Gas Production	0	0	0	-48,495	-1,668,325	1,697,063	0	0	0	0	0		-19,757	-19,757	0
2500	Coal Products	-1,825,979	1,804,466	0	-14,315	0	0	-87	0	0	0	0		-35,914	-35,914	0
2600	Oil Products	0	0	-7,923,635	8,093,693	4,667	0	0	0	0	0	-146,978		27,747	-0	27,747
2700	Other Conversions & Blending	21,802	0	0	-19,358	0	19,358	0	0	0	0	0		21,802	0	21,802
2800	Total Conversion	-4,328,140	1,434,512	-8,113,069	7,106,776	-4,065,428	1,501,427	-763,795	-711,607	-2,494,879	3,968,721	652,444		-5,813,038	-5,858,555	49,549
2900	Own Use & Loss	-21,642	-112,202	-62	-284,127	-117,728	-50,869	0	0	0	-383,100	-5,767		-975,497	-975,497	0
3000	Other Imput/Output	0	0	0	-45,609	0	0	0	0	0	0	0		-45,609	0	-45,609
3500	Stock Change	-29,283	2,534	4,692	-9,652	1,576	0	-709	0	0	0	0		-30,843	0	-30,843
4000	Stastical Discrepancy	201,162	0	26,166	-9,521	-16,273	0	-0	0	0	67	0		201,601	205,633	0
5000	Final Energy Consumption	387,167	1,338,959	0	7,471,191	66,809	1,450,558	25,714	0	0	3,585,554	646,677		14,972,628	13,230,870	1,741,758
6000	Industry	366,702	1,336,854	0	2,758,569	66,231	226,418	7,540	0	0	1,178,132	622,259		6,562,703	4,855,108	1,707,596
6100	Non-Manufacturing	78	191	0	377,978	5,064	32,929	0	0	0	9,253	0		425,493	339,881	85,612
6500	Manufacturing	366,624	1,336,663	0	2,380,591	61,167	193,489	7,540	0	0	1,168,880	622,259		6,137,210	4,515,227	1,621,984
6520	Pulp & Paper	0	0	0	14,868	334	1,852	433	0	0	113,570	207,037		338,094	338,094	0
6550	Chemical	16	40,777	0	1,803,249	33,223	6,116	251	0	0	158,027	226,833		2,268,493	732,004	1,536,488
6570	Cement & Ceramics	125,573	17,978	0	66,119	431	972	6,574	0	0	77,621	12,752		308,019	305,653	2,366
6580	Iron & Steel	253,849	975,560	0	70,809	20,314	70,130	387	0	0	247,521	99,338		1,737,907	1,737,719	188
6600	Machinery	0	4,259	0	30,096	2,604	27,765	0	0	0	282,860	0		347,583	347,583	0
6700	Duplication Adjustment	-15,889	0	0	-9,724	0	-4,013	-251	0	0	-36,304	-74,792		-140,974	-138,663	-2,311
6900	Other Industries & SMEs	1,037	290,114	0	296,349	0	12,096	0	0	0	157,635	109,653		866,885	781,632	85,253
7000	ResCom	20,421	2,105	0	1,344,445	578	1,219,473	18,175	0	0	2,339,319	24,418		4,968,935	4,968,935	0
7100	Residential	0	0	0	609,480	0	426,875	17,516	0	0	1,098,953	1,282		2,154,107	2,154,107	0
7150	HokkaidoTohoku,Hokuriku	0	0	0	214,344	0	48,592	0	0	0	193,645	0		456,581	456,581	0
7160	Kantou, Toukai, Kansai	0	0	0	274,505	0	476,774	0	0	0	751,821	0		1,503,100	1,503,100	0
7170	Chugoku,Shikoku,Kyushu,Okinawa	0	0	0	110,838	0	62,080	0	0	0	257,150	0		430,068	430,068	0
7500	Commercial & Others	20,421	2,105	0	734,965	578	792,598	658	0	0	1,240,366	23,136		2,814,827	2,814,827	0
7510	Water supply, Sewage & Waste Disposal	897	0	0	67,551	0	12,361	0	0	0	77,123	7		157,939	157,939	0
7540	Telecommunication & Broadcasting	0	0	0	11,024	0	9,840	0	0	0	31,879	815		53,558	53,558	0
7600	Trade & Finance Service	0	0	0	148,165	0	274,500	0	0	0	453,827	4,857		881,349	881,349	0
7700	Public Service	13,566	0	0	290,729	0	204,229	0	0	0	316,753	1,795		827,073	827,073	0
7810	Commercial Service	1,067	95	0	46,875	0	6,051	0	0	0	80,039	752		134,879	134,879	0
7850	Retail Service	2,180	1,974	0	198,062	0	243,008	0	0	0	181,984	1,304		628,513	628,513	0
8000	Transportation	43	0	0	3,368,177	0	4,667	0	0	0	68,103	0		3,440,991	3,406,828	34,162
8100	Passenger	43	0	0	2,068,717	0	640	0	0	0	64,877	0		2,134,278	2,108,527	25,751
8110	Car	0	0	0	1,912,806	0	70	0	0	0	0	0		1,912,876	1,887,223	25,652
8120	Rail	43	0	0	7,025	0	0	0	0	0	64,877	0		71,945	71,846	99
8130	Ship	0	0	0	50,694	0	0	0	0	0	0	0		50,694	50,694	0
8140	Air	0	0	0	115,381	0	0	0	0	0	0	0		115,381	115,381	0
8500	Freight	0	0	0	1,299,460	0	4,027	0	0	0	3,226	0		1,306,713	1,298,301	8,411
8510	Truck & Lorry	0	0	0	1,215,126	0	4,027	0	0	0	0	0		1,219,153	1,216,543	2,610
8520	Rail	0	0	0	1,449	0	0	0	0	0	3,226	0		4,675	4,596	79
8530	Ship	0	0	0	106,165	0	0	0	0	0	0	0		106,165	100,443	5,722
8540	Air	0	0	0	21,548	0	0	0	0	0	0	0		21,548	21,548	0
9000	Final Energy Consumption	387,167	1,323,788	0	5,761,202	50,209	1,450,558	25,714	0	0	3,585,554	646,677		13,230,870	13,230,870	0
9500	Non-Energy	0	15,171	0	1,709,988	16,599	0	0	0	0	0	0		1,741,758	0	1,741,758
9600	Industry	0	15,171	0	1,675,826	16,599	0	0	0	0	0	0		1,707,596	0	1,707,596
9800	ResCom & others	0	0	0	0	0	0	0	0	0	0	0		0	0	0
9850	Transport	0	0	0	34,162	0	0	0	0	0	0	0		34,162	0	34,162

Table A 2-6 Energy balance simplified table (General Energy Statistics, FY2012)

2012FY Code <Energy balance simplified table> <<Energy units>>	100 Coal TJ	150 Coal Products TJ	200 Oil TJ	250 Oil Products TJ	400 Natural Gas TJ	450 Town Gas TJ	500 New & Renewable Energy TJ	550 Large-Scale Hydraulic TJ	600 Nuclear Energy TJ	700 Electricity TJ	800 Heat TJ		900 Total TJ	910 Energy Total TJ	920 Non-Energy Total TJ
Code															
1000 Primary Energy Supply	4,873,826	29,216	8,049,332	2,228,937	4,890,689	0	841,101	657,830	138,907	0	0		21,709,837	20,168,191	1,541,646
1100 Indigenous Production	0	0	27,343	0	142,181	0	841,101	657,830	138,907	0	0		1,807,361	0	0
1200 Import	4,873,826	29,216	8,021,989	2,228,937	4,748,508	0	0	0	0	0	0		19,902,476	0	0
1500 Total Primary Energy Supply	4,873,826	29,216	8,049,332	2,228,937	4,890,689	0	841,101	657,830	138,907	0	0		21,709,837	20,168,191	1,541,646
1600 Export	-89	-43,624	0	-997,886	0	0	0	0	0	0	0		-1,041,599	0	
1700 Stockpile Change	0	2,512	14,172	-72,718	206,735	0	0	0	0	0	0		150,701	0	0
1900 Domestic Primary Energy Supply	4,873,737	-11,896	8,063,504	1,158,333	5,097,424	0	841,101	657,830	138,907	0	0	supply side	20,818,939	19,277,294	1,541,646
												consumption side	20,722,338	19,175,203	1,541,646
2000 Energy Transformation & Own use	-4,334,570	1,274,170	-8,031,221	5,990,657	-5,056,922	1,475,057	-805,849	-657,830	-138,907	3,297,538	612,468		-6,375,409	-6,484,206	114,287
2100 Power Genertion	-2,140,857	-185,062	-529,563	-901,529	-3,140,903	-79,066	-145,734	-515,913	-138,907	3,170,991	0		-4,601,053	-4,601,053	0
2200 Auto Power Generation	-239,158	-125,674	-58	-257,255	-31,369	-70,771	-324,683	-141,916	0	491,885	0		-698,999	-698,999	0
2300 Industrial Steam Generation	-208,485	-39,372	-77	-234,259	-22,008	-60,871	-330,481	0	0	0	732,558		-162,994	-162,994	0
2350 District Heat Supply	0	0	0	-172	0	-16,035	-4,332	0	0	-3,791	23,374		-957	-957	0
2400 Town Gas Production	0	0	0	-54,119	-1,710,917	1,755,849	0	0	0	0	0		-9,187	-9,187	0
2500 Coal Products	-1,748,478	1,726,134	0	-11,632	0	0	-390	0	0	0	0		-34,366	-34,366	0
2600 Oil Products	0	0	-7,493,751	7,675,338	4,143	0	0	0	0	0	-138,275		47,455	-0	47,455
2700 Other Conversions & Blending	27,688	0	0	-18,266	0	18,266	0	0	0	0	0		27,688	0	27,688
2800 Total Conversion	-4,309,290	1,376,027	-8,023,448	6,198,106	-4,901,054	1,547,372	-805,620	-657,830	-138,907	3,659,085	617,657		-5,437,902	-5,507,555	75,143
2900 Own Use & Loss	-21,903	-106,693	-100	-261,755	-147,149	-72,315	0	0	0	-361,547	-5,189		-976,651	-976,651	0
3000 Other Imput/Output	0	0	0	83,419	0	0	0	0	0	0	0		83,419	0	83,419
3500 Stock Change	-3,377	4,836	-7,673	-29,114	-8,719	0	-229	0	0	0	0		-44,276	0	-44,276
4000 Stastical Discrepancy	111,805	0	32,283	-18,863	-28,788	0	0	0	0	164	0		96,602	102,091	0
5000 Final Energy Consumption	427,363	1,262,274	0	7,167,852	69,290	1,475,057	35,252	0	0	3,297,374	612,468		14,346,929	12,690,997	1,655,932
6000 Industry	407,359	1,260,073	0	2,614,380	68,359	247,840	19,955	0	0	905,420	589,997		6,113,383	4,491,613	1,621,770
6100 Non-Manufacturing	80	191	0	396,601	5,565	35,722	0	0	0	9,262	0		447,421	358,092	89,329
6500 Manufacturing	407,279	1,259,882	0	2,217,779	62,794	212,118	19,955	0	0	896,159	589,997		5,665,962	4,133,521	1,532,441
6520 Pulp & Paper	0	0	0	13,210	469	1,964	541	0	0	107,056	190,190		313,430	313,430	0
6550 Chemical	10	41,355	0	1,692,650	32,976	6,626	465	0	0	146,862	210,148		2,131,091	684,400	1,446,692
6570 Cement & Ceramics	131,036	13,867	0	60,747	368	1,103	17,080	0	0	73,623	9,127		306,950	304,795	2,156
6580 Iron & Steel	293,184	914,563	0	67,082	22,010	67,800	1,566	0	0	243,003	100,702		1,709,910	1,709,815	95
6600 Machinery	0	4,091	0	28,712	2,498	50,525	0	0	0	260,933	0		346,760	346,760	0
6700 Duplication Adjustment	-19,716	0	0	-7,776	0	-3,251	-458	0	0	-30,876	-67,332		-129,409	-127,319	-2,090
6900 Other Industries & SMEs	951	278,198	0	269,403	0	7,160	0	0	0	-63,885	107,910		599,737	514,149	85,588
7000 ResCom	19,960	2,201	0	1,306,609	930	1,222,891	15,297	0	0	2,326,587	22,471		4,916,946	4,916,946	0
7100 Residential	0	0	0	569,982	0	426,397	14,499	0	0	1,034,434	1,204		2,046,515	2,046,515	0
7150 HokkaidoTohoku,Hokuriku	0	0	0	223,372	0	42,231	0	0	0	207,774	0		473,377	473,377	0
7160 Kantou, Toukai, Kansai	0	0	0	271,254	0	463,859	0	0	0	745,744	0		1,480,857	1,480,857	0
7170 Chugoku,Shikoku,Kyushu,Okinawa	0	0	0	112,527	0	49,070	0	0	0	255,042	0		416,639	416,639	0
7500 Commercial & Others	19,960	2,201	0	736,627	930	796,494	797	0	0	1,292,154	21,267		2,870,431	2,870,431	0
7510 Water supply, Sewage & Waste Disposal	978	0	0	64,926	0	13,252	0	0	0	77,159	6		156,322	156,322	0
7540 Telecommunication & Broadcasting	0	0	0	11,099	0	10,898	0	0	0	31,900	884		54,781	54,781	0
7600 Trade & Finance Service	0	0	0	150,155	0	326,943	0	0	0	514,298	4,206		995,602	995,602	0
7700 Public Service	12,531	0	0	284,269	0	222,698	0	0	0	301,540	1,483		822,521	822,521	0
7810 Commercial Service	1,191	47	0	39,431	0	5,287	0	0	0	78,055	686		124,697	124,697	0
7850 Retail Service	2,238	2,117	0	195,515	0	253,772	0	0	0	184,468	1,244		639,355	639,355	0
8000 Transportation	43	0	0	3,246,863	0	4,327	0	0	0	65,366	0		3,316,600	3,282,437	34,162
8100 Passenger	43	0	0	2,013,660	0	555	0	0	0	62,278	0		2,076,536	2,050,784	25,752
8110 Car	0	0	0	1,943,673	0	54	0	0	0	0	0		1,943,727	1,918,075	25,652
8120 Rail	43	0	0	6,813	0	0	0	0	0	62,278	0		69,134	69,034	100
8130 Ship	0	0	0	51,277	0	0	0	0	0	0	0		51,277	51,277	0
8140 Air	0	0	0	120,816	0	0	0	0	0	0	0		120,816	120,816	0
8500 Freight	0	0	0	1,233,204	0	3,772	0	0	0	3,088	0		1,240,063	1,231,653	8,410
8510 Truck & Lorry	0	0	0	1,133,478	0	3,772	0	0	0	0	0		1,137,250	1,134,639	2,610
8520 Rail	0	0	0	1,380	0	0	0	0	0	3,088	0		4,468	4,390	78
8530 Ship	0	0	0	107,395	0	0	0	0	0	0	0		107,395	101,672	5,722
8540 Air	0	0	0	21,038	0	0	0	0	0	0	0		21,038	21,038	0
9000 Final Energy Consumption	427,363	1,245,840	0	5,544,968	52,675	1,475,057	35,252	0	0	3,297,374	612,468		12,690,997	12,690,997	0
9500 Non-Energy	0	16,434	0	1,622,884	16,615	0	0	0	0	0	0		1,655,932	0	1,655,932
9600 Industry	0	16,434	0	1,588,721	16,615	0	0	0	0	0	0		1,621,770	0	1,621,770
9800 ResCom & others	0	0	0	0	0	0	0	0	0	0	0		0	0	0
9850 Transport	0	0	0	34,162	0	0	0	0	0	0	0		34,162	0	34,162

A2.2.2. 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 as indicated in Table A 2-7.

Values subtracting energy consumption reported under 'non-energy' [#9500] from energy consumption reported under 'energy conversion & own use' [#2000], 'industry' [#6000], 'residential' [#7100], 'commercial & others' [#7500], and 'transportation' [#8000] in *General Energy Statistics* (Energy Balance Table) are used for activity data. Because energy consumption reported under 'non-energy' [#9500] 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 *Revised 1996 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 industrial steam generation are presented under 'auto power generation' [#2200], 'industrial steam generation' [#2300] in the energy conversion sector. However, auto power generation and industrial steam generation actually belong to industrial sector. Hence, carbon dioxide emissions from "auto power generation" and "industrial steam generation" are allocated to each section of '1.A.2 Manufacturing industries and construction'.

Table A 2-7 Correspondence between sectors of General Energy Statistics (Miner Sector) and of the CRF

CRF			Japan's Energy Balance Table	
1A1		Energy industries		
	1A1a	Public electricity and heat production	Power generation, general electric utilities	#2110
			Own use, general electric utilities	#2911
			Power generation, independent power production	#2150
			Own use, independent power production	#2912
			District heat supply	#2350
			Own use, district heat supply	#2913
	1A1b	Petroleum refining	Own use, oil refinery	#2916
	1A1c	Manufacture of solid fuels and other energy industries	Coal products	#2500
			Own use, town gas	#2914
			Own use, steel coke	#2915
			Own use, other conversion	#2917
1A2		Manufacturing industries and construction		
	1A2a	Iron and steel	Auto, iron & steel	#2217
			Steam generation, iron & steel	#2307
			Final energy consumption, iron & steel	#6580
			Non-energy, iron & steel	#9680
	1A2b	Non-ferrous metals	Auto, non-ferrous metal	#2218
			Steam generation, non-ferrous metal	#2308
			Final energy consumption, non-ferrous metal	#6590
			Non-energy, non-ferrous metal	#9690
	1A2c	Chemicals	Auto, chemical textiles	#2212
			Steam generation, chemical textiles	#2302
			Final energy consumption, chemical textiles	#6530
			Non-energy, chemical textiles	#9630
			Auto, chemical	#2214
			Steam generation, chemical	#2304
			Final energy consumption, chemical	#6550
			Non-energy, chemical	#9650
	1A2d	Pulp, paper and print	Auto, pulp & paper	#2211
			Steam generation, pulp & paper	#2301
			Final energy consumption, pulp & paper	#6520
			Non-energy, pulp & paper	#9620
	1A2e	Food processing, beverages and tobacco	Final energy consumption, food	#6510
			Non-energy, non-manufacturing industry (food)	#9610
	1A2f	Other		
		Mining	Final energy consumption, mining	#6120
			Non-energy, non-manufacturing industry (mining)	#9610
		Construction	Final energy consumption, construction	#6150
			Non-energy, non-manufacturing industry (construction)	#9610
		Oil products	Auto, oil products	#2213
			Steam generation, oil products	#2303
			Final energy consumption, oil products	#6540
			Non-energy, oil products	#9640
		Glass wares	Auto, glass wares	#2215
			Steam generation, glass wares	#2305
			Final energy consumption, glass wares	#6560
			Non-energy, glass wares	#9660
		Cement & ceramics	Auto, cement & ceramics	#2216
			Steam generation, cement & ceramics	#2306
			Final energy consumption, cement & ceramics	#6570
			Non-energy, cement & ceramics	#9670
		Machinery	Auto, machinery & others	#2219
			Steam generation, machinery & others	#2309
			Final energy consumption, machinery	#6600
			Non-energy, machinery	#9700
		Duplication adjustment	Auto, duplication adjustment	#2220
			Steam generation, duplication adjustment	#2310
			Final energy consumption, duplication adjustment	#6700
			Non-energy, duplication adjustment	#9710
		Other industries & small and medium enterprises	Auto, others	#2250
			Final energy consumption, other industries & small and medium enterprises	#6900
			Non-energy, other industries & small and medium enterprises	#9720

Table A 2-7 Correspondence between sectors of General Energy Statistics (Miner Sector) and of the CRF (cont.)

CRF			Japan's Energy Balance Table	
1A3		Transport		
	1A3a	Civil aviation	Final energy consumption, passenger air	#8140
			Final energy consumption, freight air	#8540
			Non-energy, transportation (air)	#9850
	1A3b	Road transportation	Final energy consumption, passenger car	#8110
			Final energy consumption, freight, freight truck & lorry	#8510
			Final energy consumption, passenger bus	#8115
			Final energy consumption, passenger, transportation fraction estimation error	#8190
			Final energy consumption, freight, transportation fraction estimation error	#8590
			Non-energy, transportation (car, truck & lorry, bus)	#9850
	1A3c	Railways	Final energy consumption, passenger rail	#8120
			Final energy consumption, freight rail	#8520
			Non-energy, transportation (rail)	#9850
	1A3d	Navigation	Final energy consumption, passenger ship	#8130
			Final energy consumption, freight ship	#8530
			Non-energy, transportation (ship)	#9850
	1A3e	Other transportation	-	-
1A4		Other sectors		
	1A4a	Commercial/institutional	Final energy consumption, commercial & others	#7500
			Non-energy, residential, commercial & others (commercial & others)	#9800
	1A4b	Residential	Final energy consumption, residential	#7100
			Non-energy, residential, commercial & others (residential)	#9800
	1A4c	Agriculture/forestry/fisheries	Final energy consumption, agriculture, forestry & fishery	#6110
			Non-energy, non-manufacturing industry (Agruculture, Forestry & Fishery)	#9610
1A5		Other		
	1A5a	Stationary	-	-
			-	-
	1A5b	Mobile	-	-

・Auto: Non-utility power generation

・#9xxx items are subtracted as a Non- energy use activity.

In 'energy conversion & own use', 'power generation' [#2100], 'auto power generation' [#2200] , 'industrial steam generation' [#2300] , 'district heat supply' [#2350] , 'coal products' [#2500] , and 'own use & loss' [#2900] are calculated, and other sectors ('town gas production', 'oil products', 'other conversions & blending', 'other input/output' and 'stock change') are excluded from calculations.

Energy consumptions reported under 'town gas production' correspond to the amount put as feedstock of town gas, and are not used for combustion purpose. Therefore, they are excluded from calculations. Meanwhile, CO_2 emissions from carbon contained in these feedstocks are calculated with town gas consumption in final energy consumption sector (industry, residential, commercial & others, and transportation).

The energy consumption recorded under coal products corresponds to the difference between the coke-making carbon input and carbon output. This is 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 reported under ‘oil products’ are feedstock for oil products, and are not used for the purpose of combustion. Meanwhile, CO_2 emissions from carbon contained in these feedstocks are calculated with each kind of energy consumption in energy conversion sector and final energy consumption sector (industry, residential, commercial & others, and transportation).

A2.2.3. 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. The Yearbook of the Current Survey of Energy Consumption* is a statistical survey on factories and business institutions of key manufacturing. Factories and business institutions which produce items indicated in Table A 2-8 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 item and total energy consumption by factory and 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, industrial steam generation, and manufacturing.

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 2-8, 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 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, other industries, and small-to-medium-sized manufacturing significantly fluctuates.

Table A 2-8 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 amonia-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 amonia-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 cold working steel pipes), or cast iron tubes. Iron and steel.	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 cold working steel pipes), or cast iron tubes. Iron and steel.	All
Non-ferrous metal industry	* Non-ferrous metals	All	* Copper * Lead * Zinc * Aluminum * Alminum secondary ground metal	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 electrictronics equipment, electron tubes, semiconductors, ICs, 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	

A2.3. 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 2-9 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 2-9 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 mm^2/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 Estimation of CO_2 Emissions in Japan*, 1992.
2. Research Institute of Economy, Trade & Industry, Kazunari Kaino, *Interpretation of General Energy Statistics*, 2009.
3. Japanese Industrial Standards K 2204, revised in 2007.

Annex 3. Other Detailed Methodological Descriptions for Individual Source or Sink Categories

In this Annex 3, "Additional Information for CH_4 and N_2O Emissions from Stationary Combustion" (A3.1.) and "Methodology for Estimating Emissions of Precursors" (A3.2.) are described.

A3.1. Additional Information for CH_4 and N_2O Emissions from Stationary Combustion (1.A.1., 1.A.2. and 1.A.4.)

A3.1.1. Summary of Emission Factors

Japan has accumulated data through a considerable amount of actual past measurements relating to non-CO_2 emissions from stationary combustion. The CH_4 and N_2O emission factors by fuel type and furnace type established based on the results of a study involving actual measurements are shown in Table A 3-1 and Table A 3-2.

Table A 3-1 and Table A 3-2 show two types of emission factors ("with air-intake adjustment," and "without air-intake adjustment"), but the emission calculations for the GHG inventory use the "without air-intake adjustment" emission factors (for emission factors "with air-intake adjustment," please refer to A3.1.3. below).

Table A 3-1 CH_4 emission factors by fuel and furnace[1] (unit: kg-CH_4/TJ)

Furnace type	Fuel type[2]	Emission factor (without air-intake adjustment)		Emission factor (with air-intake adjustment)	
		Value	Remarks	Value	Remarks
Boiler	Fuel oils B and C, crude oil	0.10	Average of 9 facilities	-0.32	Average of 9 facilities
Boiler	Fuel oil A, diesel oil, kerosene, naphtha, other liquid fuels	0.26	Average of 2 facilities	-0.30	Average of 2 facilities
Boiler	Gaseous fuel	0.23	Average of 5 facilities	-0.29	Average of 5 facilities
Boiler	Steam coal, coke, other solid fuels	0.13	Average of 7 facilities	-0.45	Average of 7 facilities
Boiler	Harvested wood, charcoal	75	Average of 4 facilities	74	Average of 4 facilities
Boiler	Pulping waste liquor	4.3	Average of 2 facilities	3.9	Average of 2 facilities
Sintering furnace for smelting of metals (except copper, lead, and zinc)	Solid fuel, liquid fuel, gaseous fuel	31	Average of 6 facilities	30	Average of 6 facilities
Pelletizing furnace (steel and non-ferrous metal)	Solid fuel, liquid fuel, gaseous fuel	1.7	Average of 2 facilities	0.16	Average of 2 facilities
Metal rolling furnace, metal treating furnace, metal forging furnace	Liquid fuel, gaseous fuel	0.43	Average of 11 facilities	-0.22	Average of 12 facilities
Petroleum and gas furnaces	Liquid fuel, gaseous fuel	0.16	Average of 27 facilities	-0.28	Average of 27 facilities
Catalytic regenerator	Coke, carbon	0.054	Average of 11 facilities	-0.24	Average of 11 facilities
Brick kiln, ceramic kiln, and other kiln	Solid fuel, liquid fuel, gaseous fuel	1.5	Average of 2 facilities	-0.43	Average of 2 facilities
Aggregate drying kiln, cement raw material drying kiln, brick raw material drying kiln	Solid fuel, liquid fuel, gaseous fuel	29	Average of 6 facilities	27	Average of 6 facilities
Other drying kilns	Solid fuel, liquid fuel, gaseous fuel	6.6	Average of 8 facilities	3.4	Average of 8 facilities
Electric arc furnace[3]	Electricity	13	Average of 6 facilities	5.6	Average of 6 facilities
Other industrial furnaces	Solid fuel	13	Average of 14 facilities	12	Average of 14 facilities
Other industrial furnaces	Liquid fuel	0.83	Average of 14 facilities	-0.13	Average of 15 facilities
Other industrial furnaces	Gaseous fuel	2.3	Average of 6 facilities	0.63	Average of 6 facilities
Gas turbine	Liquid fuel, gaseous fuel	0.81	Average of 11 facilities	-0.44	Average of 11 facilities
Diesel engine	Liquid fuel, gaseous fuel	0.70	Average of 8 facilities	-0.28	Average of 8 facilities
Gas engine, petrol engine	Liquid fuel, gaseous fuel	54	Average of 6 facilities	54	Average of 6 facilities

[1] The emission calculations for the GHG inventory use the "without air-intake adjustment" emission factors (for emission factors "with air-intake adjustment," please refer to A3.1.3. below)

[2] The classification of fuel type under normal temperature and pressure conditions (For example, coking coal, coke-oven gas, blast-furnace gas, and converter-furnace gas are classified as not solid fuels but gaseous fuels.) The criterion of the classification of fuel type in Table A 3-2 is also the same as this table.

[3] Methane emissions from electric arc furnaces are reported under the Industrial Processes sector.

Table A 3-2 N_2O emission factors by fuel and furnace (unit: kg-N_2O/TJ)

Furnace type	Fuel type	Emission factor (without air-intake adjustment)		Emission factor (with air-intake adjustment)	
		Value	Remarks	Value	Remarks
Boiler	Fuel oils B and C, crude oil	0.22	Average of 10 facilities	0.017	Average of 10 facilities
Boiler	Fuel oil A, diesel oil, kerosene, naphtha, other liquid fuels	0.19	Average of 2 facilities	-0.078	Average of 2 facilities
Boiler	Gaseous fuel	0.17	Average of 5 facilities	-0.075	Average of 5 facilities
Boiler (other than fluidized-bed boiler)	Solid fuel	0.85	Average of 9 facilities	0.58	Average of 9 facilities
Normal pressure fluidized-bed boiler	Solid fuel	54	Average of 11 facilities	54	Average of 11 facilities
Pressurized fluidized-bed boiler	Steam coal	5.2	Data from 1 facility	5.0	Data from 1 facility
Boiler	Pulping waste liquor	0.17	Average of 2 facilities	-0.015	Average of 2 facilities
Blast furnace	Coke oven gas, blast furnace gas, other gaseous fuel	0.047	Average of 2 facilities	-0.097	Average of 2 facilities
Petroleum furnace, gas furnace	Liquid fuel, gaseous fuel	0.21	Average of 27 facilities	0.00069	Average of 27 facilities
Catalytic regenerator	Coke, carbon	7.3	Average of 12 facilities	7.2	Average of 12 facilities
Electric arc furnace[4]	Electricity	3.3	Average of 6 facilities	-0.14	Average of 6 facilities
Coke oven	Town gas, coke oven gas, blast furnace gas, converter gas, off-gas, other gaseous fuels	0.14	Average of 3 facilities	-0.025	Average of 3 facilities
Other industrial furnace	Solid fuel	1.1	Average of 20 facilities	0.66	Average of 20 facilities
Other industrial furnace	Liquid fuel	1.8	Average of 31 facilities	1.0	Average of 31 facilities
Other industrial furnace	Gaseous fuel	1.2	Average of 18 facilities	0.14	Average of 18 facilities
Gas turbine	Liquid fuel, gaseous fuel	0.58	Average of 12 facilities	0.078	Average of 12 facilities
Diesel engine	Liquid fuel, gaseous fuel	2.2	Average of 9 facilities	1.7	Average of 9 facilities
Gas engine, petrol engine	Liquid fuel, gaseous fuel	0.85	Average of 7 facilities	0.62	Average of 7 facilities

A3.1.2. Calculation of Emission Factors by Fuel Type

For reference, the details of setting CH_4 and N_2O emission factors by fuel type from boilers, which are widely utilized beyond categories, are described in this section. Please refer to *GHGs Estimation Methods Committee Report Part 1* (Ministry of the Environment, Committee for the Greenhouse Gases Emissions Estimation Methods, August 2006) for the details of emission factors of other furnaces.

The symbols and numbers used in Table A 3-3 through Table A 3-15 to indicate emission factor data are explained in the legend below.

[4] No N_2O emissions occur from electric arc furnaces, because N_2O concentrations measured are almost in agreement with the ambient concentration (0.31 ppm).

Legend: Symbols and Numbers in Table A 3-3 to Table A 3-15

- *1 indicates that the data were not used in calculating averages, as they were rejected by outlier tests (1% significance level).
- *2 indicates that the data were used in calculating averages, as experts judged that they should not be excluded, even though they were rejected by outlier tests (1% significance level).
- *3 indicates that the data were not used in calculating averages, as experts judged that they should be rejected.

See 3.2.2.b) table 3-10 of Chapter 3 for data sources listed in the sources column.

A3.1.2.1. Calculation of CH_4 Emission Factors from Boilers by Fuel Type

A3.1.2.1.a. Liquid Fuels

For liquid fuels, emission factors were determined after classifying the fuels into heavy oils (Fuel oil C, Fuel oil B, crude oil) and light oils (Fuel oil A, gas/diesel oil, kerosene, naphtha, other liquid fuels (gasoline, etc.)). Generally, heavy oils are used in large boilers, and light oils are used in small boilers. The average of 9 facilities that use Fuel oil C is used for boilers that use heavy oil, and the average of 2 facilities that use Fuel oil A is used for boilers that use light oil.

Table A 3-3 Individual data and average emission factors used to determine CH_4 emission factors for boilers (Fuel oil C, Fuel oil B, crude oil)

Furnace type, operating conditions	Fuel type	G [m^{3}N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Other, continuous	Fuel oil C	854000	2.5	0.5	0.093	-0.260	9
Boilers (for electricity) single vessel radiative reheating type, secondary combustion	Fuel oil C	419000	4.8	0.235	0.050	-0.353	2
Boilers (for electricity) heavy oil mist combustion, continuous furnace, single vessel radiative type	Fuel oil C	8000	11.0	1.2	0.424	-0.230	23
Other, continuous	Fuel oil C	476164	5.8	3.32	*1 0.759	*1 0.329	14
Boiler (other) circular tube liquid combustion furnace, continuous	Fuel oil C	26497	15.5	0.8	*3 0.405	*3 -0.784	7
			15.5	0.5			
			15.5	0.57			
Circular tube liquid combustion furnace, continuous	Fuel oil C	46000	5.1	0.61	0.124	-0.288	7
			5.1	0.55			
			5.1	0.54			
Other, continuous	Fuel oil C	50490	8.6	0.57	0.161	-0.366	9
Other, continuous	Fuel oil C	—	1.4	0.2	0.035	-0.299	29
Other, continuous	Fuel oil C	—	4.0	0.07	0.014	-0.370	29
Other, continuous	Fuel oil C	—	1.5	0.19	0.033	-0.302	29
Other, continuous	Fuel oil C	—	4.0	0.04	0.008	-0.377	29
	Fuel oil B, Fuel oil C, crude oil, simple mean value				0.105	-0.316	

G : Actual measured dry emission gas amount

C_{O2} : Specific oxygen concentration

C_{CH4} : Specific CH_4 concentrations measured

EF : Emission factor (without air-intake adjustment)

EF_{adj} : Emission factor (with air-intake adjustment)

Table A 3-4 Individual data and average emission factors used to determine CH_4 emission factors for boilers (Fuel oil A, gas/diesel oil, kerosene, naphtha, other liquid fuels)

Furnace type, operating conditions	Fuel type	G [m^{3}N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Boiler (other (furnace pipe flue type)), continuous	Fuel oil A	5980	6.7	0.09	0.022	-0.437	4
Steam boiler, continuous	Fuel oil A	10993	11.0	1.4	0.495	-0.161	23
	Fuel oil A, simple mean value				0.258	-0.299	

A3.1.2.1.b. Gaseous Fuels

For boilers that use gaseous fuels, the emission factor was set by using the average value of 5 facilities that use LNG or town gas as fuel.

Table A 3-5 Individual data and average emission factors used to determine CH_4 emission factors for boilers (gaseous fuels)

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Boiler (for electricity) other, continuous	LNG	898000	3.8	0.16	0.030	-0.347	10
			3.8	0.14			
			3.8	0.13			
			3.9	0.2			
Other, continuous	LNG	1942860	1.8	2.11	0.358	0.021	14
Boiler (for electricity)	LNG	590000	3.2	*3 8.2	0.093	-0.272	30
				0.5			
				0.5			
Boiler (for electricity)	LNG	8083.8	14.5	1.05	0.522	-0.412	8
			13.6	0.97			
			14.0	1.1			
Continuous	Town gas (13A)	6000	9.8	0.5	0.150	-0.420	30
			9.7	0.5			
			9.7	0.5			
	Gaseous fuels, simple mean				0.231	-0.286	

A3.1.2.1.c. Solid Fuels (Excluding Wood, Charcoal)

For boilers that use solid fuels (excluding wood, charcoal), the emission factor was set by using the average value of 7 facilities that use steam coal as fuel.

Table A 3-6 Individual data and average emission factors used to determine CH_4 emission factors for boilers (solid fuels (excluding wood, charcoal))

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Stoker furnace, continuous	Steam coal	43000	10.5	0.38	0.153	-0.601	4
Powdered coal combustion furnace, continuous	Steam coal	702000	7.6	0.35	0.109	-0.482	1
Powdered coal combustion furnace, continuous	Steam coal	624000	5.4	0.25	0.067	-0.441	4
Powdered coal combustion furnace, continuous	Steam coal	2080000	5.4	0.36	0.098	-0.409	12
			5.4	0.38			
			5.4	0.37			
Powdered coal combustion furnace, continuous	Coal	455339	5.5	0.27	0.072	-0.438	28
Stoker furnace, batch	Steam coal	4040	13.5	2.1	*1 1.198	*1 0.143	4
Powdered coal combustion furnace, continuous	Steam coal	46300	8.2	0.3	0.098	-0.520	16
Powdered coal combustion furnace, continuous (Single vessel radiative natural cycle)	Steam coal	159000	7.0	1.2	0.318	-0.247	13
				1			
				1			
	Solid fuels, simple mean				0.131	-0.448	

A3.1.2.1.d. Wood, Charcoal

For wood and charcoal boilers, the emission factor was set by using the average value of 4 facilities that use wood as fuel.

Table A 3-7 Individual data and average emission factors used to determine CH_4 emission factors for boilers (wood, charcoal)

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Stoker furnace, continuous	Wood	49000	7.9	[*3] 0.8	[*3] 0.178	[*3] -0.350	30
			7.3	[*3] 0.5			
			8.0	[*3] 0.6			
Fluidized bed furnace, continuous	Wood	68400	7.7	561	156.299	155.774	4
Stoker furnace	Wood	46000	5.8	170	49.015	48.544	30
			6.2	180			
			6.5	240			
Fixed bed furnace, continuous	Wood	6290	16.6	94	81.715	80.126	16
Fixed bed furnace, continuous	Wood	4260	15.8	17.2	12.616	11.272	16
	Wood, simple mean				74.911	73.929	

A3.1.2.1.e. Pulping Waste Liquor

For boilers that use pulping waste liquor (black liquor), the emission factor was set by using the average value of 2 facilities.

Table A 3-8 Individual data and average emission factors used to determine CH_4 emission factors for boilers (pulping waste liquor)

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{CH4} [ppm]	EF [kg-CH_4/TJ]	EF_{adj} [kg-CH_4/TJ]	Source
Other (pressurized mist type), continuous	Pulping waste liquor	179000	3.0	24.4	4.801	4.423	4
Other, batch	Pulping waste liquor	114000	[*3] 10.5	0.38	[*3] 0.132	[*3] -0.516	26
Continuous	Pulping waste liquor	44000	4.2	28.8	3.841	3.431	30
			4.5	18.7			
			4.6	6.4			
	Liquid pulp waste, simple mean				4.321	3.927	

A3.1.2.2. Calculation of N_2O Emission Factors from Boilers by Fuel Type

A3.1.2.2.a. Liquid Fuels

For liquid fuels, emission factors were determined after classifying the fuels into heavy oils (Fuel oil C, Fuel oil B, crude oil) and light oils (Fuel oil A, gas/diesel oil, kerosene, naphtha, other liquid fuels (gasoline, etc.)). Generally, heavy oils are used in large boilers, and light oils are used in small boilers. The average of 10 facilities that use Fuel oil C is used for boilers that use heavy oil, and the average of 2 facilities that use Fuel oil A is used for boilers that use light oil.

Table A 3-9 Individual data and average emission factors used to determine N_2O emission factors for boilers (Fuel oil C, Fuel oil B, crude oil)

Furnace type, operating conditions	Fuel type	*G* [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	*EF* [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Other, continuous	Fuel oil C	854000	2.5	0.1	0.051	-0.116	9
Boilers (for electricity) single vessel radiative reheating type, secondary combustion	Fuel oil C	419000	4.8	0.37	0.218	0.027	2
Boilers (for electricity) heavy oil mist combustion, continuous furnace, single vessel radiative type	Fuel oil C	8000	11.0	0.3	0.291	-0.018	23
Other, continuous	Fuel oil C	476164	5.8	0.319	0.201	-0.003	14
Boiler (other) circular tube liquid combustion furnace, continuous	Fuel oil C	26497	[*3] 15.5	0.65	[*1] 1.299	[*1] 0.736	7
			[*3] 15.5	0.69			
			[*3] 15.5	0.84			
Circular tube liquid combustion furnace, continuous	Fuel oil C	46000	5.1	0.38	0.228	0.033	7
			5.1	0.38			
			5.1	0.38			
Other, continuous	Fuel oil C	50490	8.6	0.4	0.311	0.061	9
Other, continuous	Fuel oil C	—	1.4	0.51	0.246	0.088	29
Other, continuous	Fuel oil C	—	4.0	0.33	0.185	0.002	29
Other, continuous	Fuel oil C	—	1.5	0.43	0.208	0.049	29
Other, continuous	Fuel oil C	—	4.0	0.41	0.229	0.047	29
	Fuel oil B, Fuel oil C, crude oil, simple mean value				0.217	0.017	

G : Actual measured dry emission gas amount

C_{O2} : Specific oxygen concentration

C_{N2O} : Specific N_2O concentrations measured

EF : Emission factor (without air-intake adjustment)

EF_{adj} : Emission factor (with air-intake adjustment)

Table A 3-10 Individual data and average emission factors used to determine N_2O emission factors for boilers (Fuel oil A, gas/diesel oil, kerosene, naphtha, other liquid fuels)

Furnace type, operating conditions	Fuel type	*G* [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	*EF* [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Boiler (other (furnace pipe flue type)), continuous	Fuel oil A	5980	6.7	0.12	0.080	-0.137	4
Steam boiler, continuous	Fuel oil A	10993	11.0	0.3	0.292	-0.019	23
	Fuel oil A, simple mean value				0.186	-0.078	

A3.1.2.2.b. Gaseous Fuels

For boilers that use gaseous fuels, the emission factor was set by using the average value of 4 facilities that use LNG or town gas as fuel.

Table A 3-11 Individual data and average emission factors used to determine N_2O emission factors for boilers (gaseous fuels)

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	EF [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Boiler (for electricity) other, continuous	LNG	898000	3.8	0.37	0.182	0.004	10
			3.8	0.38			
			3.8	0.37			
			3.9	0.26			
Other, continuous	LNG	1942860	1.8	0.311	0.145	-0.014	14
Boiler (for electricity)	LNG	590000	3.2	0.146	0.043	-0.129	30
				0.052			
				0.057			
Boiler (for electricity)	LNG	8083.8	14.5	0.237	0.328	-0.114	8
			13.6	0.234			
			14.0	0.242			
Continuous	Town gas (13A)	6000	9.8	*3 2.91	0.148	-0.122	30
			9.7	0.19			
			9.7	0.17			
	Gaseous fuels, simple mean				0.169	-0.075	

A3.1.2.2.c. Solid Fuels

For boilers that use solid fuels, the emission factors of fluidized-bed boilers are significantly different from those of other boilers. In addition, among fluidized-bed boilers, the emission factor of normal pressure fluidized-bed boilers is different from that of pressurized fluidized-bed boilers.

For boilers other than fluidized-bed boilers that use solid fuels, the emission factor was set by using the average value of 9 facilities that use steam coal or wood as fuel. For normal pressure fluidized-bed boilers, the emission factor was set by using the average value of 11 facilities. For pressurized fluidized-bed boilers, the emission factor was set by using the average value of 1 facility.

Table A 3-12 Individual data and average emission factors used to determine N_2O emission factors for boilers (solid fuels, other than fluidized-bed boilers)

Furnace type, operating conditions	Fuel type	G [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	EF [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Stoker furnace, continuous	Steam coal	43000	10.5	0.56	0.621	0.264	4
Stoker furnace, continuous	Wood	49000	7.9	1.05	0.611	0.361	30
			7.3	0.69			
			8.0	0.64			
Powdered coal combustion furnace, continuous	Steam coal	702000	7.6	1.15	0.988	0.708	1
Powdered coal combustion furnace, continuous	Steam coal	624000	5.4	1.04	0.761	0.521	4
Powdered coal combustion furnace, continuous	Steam coal	2080000	5.4	0.24	0.173	-0.067	12
			5.4	0.23			
			5.4	0.24			
Powdered coal combustion furnace, continuous	Coal	455339	5.5	0.527	0.388	0.146	28
Stoker furnace, batch	Steam coal	4040	13.5	2.65	*1 4.158	*1 3.658	4
Powdered coal combustion furnace, continuous	Steam coal	46300	8.2	2.44	2.199	1.907	16
Stoker furnace	Wood	46000	5.8	0.58	1.137	0.913	30
			6.2	1.32			
			6.5	3.03			
Fixed bed furnace, continuous	Wood	6290	16.6	1.08	*3 2.582	*3 1.829	16
Fixed bed furnace, continuous	Wood	4260	15.8	0.53	*3 1.069	*3 0.432	16
Powdered coal combustion furnace, continuous (Single vessel radiative natural cycle)	Steam coal	159000	7.0	0.9	0.759	0.491	13
				1			
				0.9			
				0.9			
	Solid fuels, simple mean (other than fluidized bed)				0.849	0.583	

Table A 3-13 Individual data and average emission factors used to determine N_2O emission factors for boilers (solid fuels, normal pressure fluidized-bed boilers)

Furnace type, operating conditions	Fuel type	*G* [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	*EF* [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Fluidized bed furnace, continuous	Steam coal	165000	5.4	79.9	58.471	58.231	26
Fluidized bed furnace, continuous	Steam coal	223000	6.8	76.9	62.155	61.891	16
Fluidized bed furnace, continuous	Steam coal	209419	5.5	43.7	31.388	31.146	5
			5.5	41.4			
			5.5	42.7			
Fluidized bed furnace, continuous	Steam coal	1043000	5.7	91	67.978	67.733	21
Fluidized bed furnace, continuous	Steam coal	176000	5.6	94.3	68.358	68.116	6
			5.5	92.2			
			5.4	91.8			
Fluidized bed furnace, continuous	Wood	68400	7.7	83.3	63.822	63.573	4
Fluidized bed furnace, continuous	Steam coal, industrial waste	63800	6.5	69.5	54.949	54.690	1
Fluidized bed furnace, continuous	Steam coal	71000	10.5	68.5	79.695	79.338	30
			10.5	73.7			
			10.5	73.5			
Fluidized bed furnace, continuous	Coal	250918	4.3	39.72	27.039	26.814	28
Fluidized bed furnace, continuous	Steam coal	31900	4.8	23.3	15.996	15.765	12
			4.7	23.3			
			4.8	21.8			
Fluidized bed furnace, continuous	Steam coal	185000	6.6	86	68.492	68.232	22
	Solid fuels, simple mean (fluidized-bed)				54.395	54.139	

Table A 3-14 Individual data and average emission factors used to determine N_2O emission factors for boilers (solid fuels, pressurized fluidized-bed boilers)

Furnace type, operating conditions	Fuel type	*G* [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	*EF* [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Pressurized fluidized-bed boiler, continuous	Steam coal	—	3.8	9.0	5.249	5.032	31
			3.6	7.0			
	Simple mean				5.249	5.032	

A3.1.2.2.d. Pulping Waste Liquor

For boilers that use pulping waste liquor (black liquor), the emission factor was set by using the average value of 2 facilities.

Table A 3-15 Individual data and average emission factors used to determine N_2O emission factors for boilers (liquid pulp waste)

Furnace type, operating conditions	Fuel type	*G* [m^3N/h]	C_{O2} [%]	C_{N2O} [ppm]	*EF* [kg-N_2O/TJ]	EF_{adj} [kg-N_2O/TJ]	Source
Boiler (for electricity) other (pressurized mist type), continuous	Pulping waste liquor	179000	3.0	0.13	0.070	-0.109	4
Boiler (for electricity) other, batch	Pulping waste liquor	114000	[*3] 10.5	0.44	[*3] 0.419	[*3] 0.113	26
Boiler (for electricity), continuous	Pulping waste liquor	44000	4.2	0.47	0.274	0.079	30
			4.5	0.46			
			4.6	0.46			
	Pulping Waste Liquor, simple mean				0.172	-0.015	

A3.1.3. Emission Factors with Air-Intake Adjustment

In Japan, until the inventory submitted in 2005, based on the results of past discussions (e.g., Japan Society for Atmospheric Environment, *Reports on Greenhouse Gas Emissions Estimation Methodology*, 1996) relating to methodologies for calculating emissions, the non-CO_2 emission factors from stationary combustion were established after taking into account the difference between emission gas concentrations and intake gas concentrations (i.e., air-intake adjustment). For some emission sources, negative values were given for emission factor, based on measurement data showing that concentrations in emission gas were lower than in intake gas, as 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 in 2003, Japan was informed that although it should make air-intake adjustments in order to enable accurate determination of emissions amounts, it was pointed out that in the interest of international comparison, the *1996 Revised IPCC Guidelines* as well as *GPG (2000)* indicate that for calculations of emissions, positive emission factors should be used, based on actual emissions of CH_4 and N_2O in emissions gases. Thus, in the inventories submitted in 2006 and thereafter, it was decided not to make the air-intake adjustment, and that emission factors would be determined by using the actual measurements of CH_4 and N_2O concentrations in emission gases.

In the event that the air-intake adjustment was to be done, however, the equations for the CH_4 and N_2O emission factor would be as shown below.

<u>Facilities Other than Electric Arc Furnaces</u>

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

EF	:	Emission factor [kg-CH_4/TJ, kg-N_2O/TJ]
$C_{CH4,N2O}$	:	CH_4 and N_2O concentration in emission gas [ppm]
G_0'	:	Theoretical amount of emission gas (dry) from combusted fuel [m^3N/original unit]
A_0	:	Theoretical amount of air from combusted fuel [m^3N/original unit]
m	:	Air ratio ≡ Actual air amount / theoretical air amount [-]
MW	:	Molecular weight of CH_4 (constant) = 16 [g/mol] Molecular weight of N_2O (constant) = 44 [g/mol]
V_m	:	Volume of 1 mole of ideal gas under normal conditions (constant) = 22.4 [$10^{-3}m^3$/mol]
GCV	:	Gross calorific value of combusted fuel [MJ/ original unit]
C_{env}	:	Ambient concentration of CH_4 (constant) = 1.80 [ppm] Ambient concentration of N_2O (constant) = 0.31 [ppm] (Source: *Reports on Greenhouse Gas Emissions Estimation Methodology*, Japan Society for Atmospheric Environment, 1996)

$$m = \frac{21}{21 - C_{O2}}$$

C_{O2}	:	O_2 concentration in emission gas [%]

<u>Electric Arc Furnaces</u>

$$EF = (C_{CH_4,N_2O} - C_{env}) \times G \times MW / V_m / H$$

EF	:	Emission factor [kg-CH_4/TJ, kg-N_2O/TJ]
$C_{CH4,N2O}$	:	CH_4 and N_2O concentration in emission gas [ppm]
C_{env}	:	Ambient concentration of CH_4 (constant) = 1.80 [ppm] Ambient concentration of N_2O (constant) = 0.31 [ppm] (Source: *Reports on Greenhouse Gas Emissions Estimation Methodology*, Japan Society for Atmospheric Environment, 1996)
G	:	Actual measured dry emission gas amount per unit of time [m^3N/h]
MW	:	Molecular weight of CH_4 (constant) = 16 [g/mol]

Molecular weight of N_2O (constant) = 44 [g/mol]

V_m : Volume of 1 mole of ideal gas under normal conditions (constant) = 22.4 [10^{-3} m^3/mol]

H : Amount of heat generated per unit of time [MJ/h]

For reference, Table A 3-1 and Table A 3-2 shows the CH_4 and N_2O emission factors that would be used if the air-intake adjustments were to be conducted.

A3.1.4. Confirmation of the Validity of the Emission Factors of Fuel Combustion

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)

Therefore, actual measurements were conducted in FY2009 for the N_2O emission factors 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.

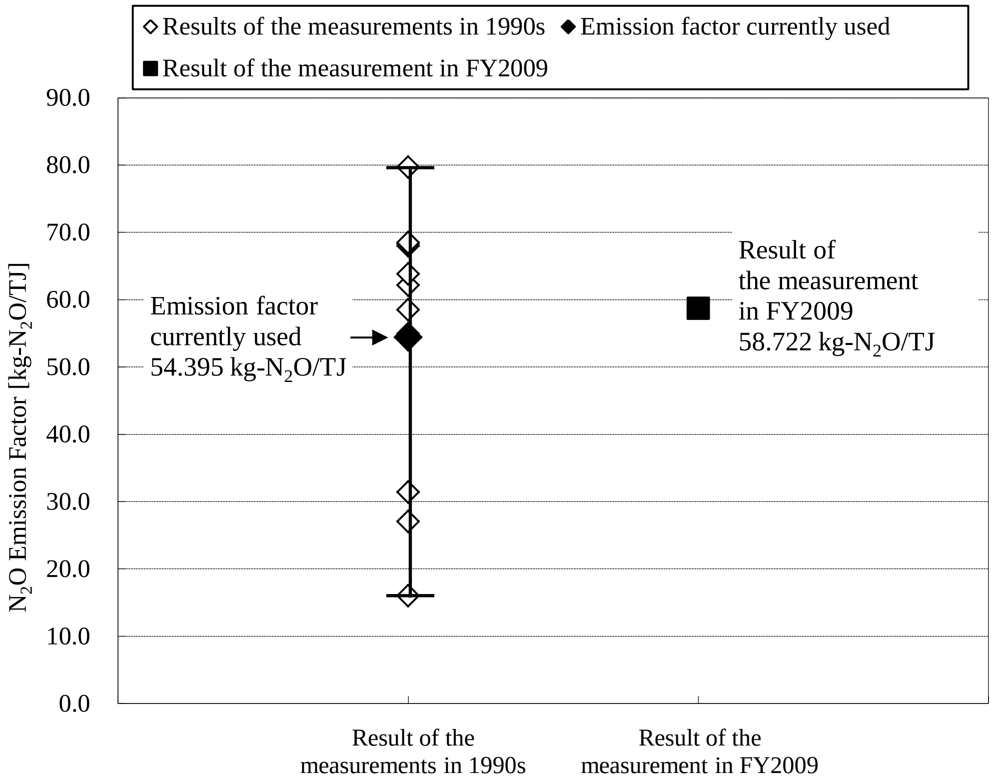

Figure A 3-1 Comparison of the 1990s and FY2009 measurement results

A3.2. Methodology for Estimating Emissions of Precursors

In addition to the greenhouse gases (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, SF_6) reported under the Kyoto Protocol, Japan reports on the emissions of precursors (NO_X, CO, NMVOC, SO_2) calculated by established methods. This section explains the source categories for which methodologies for estimating emissions have been provided.

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 historical investigations.

A3.2.1. Energy Sector

A3.2.1.1. Stationary Combustion (1.A.1., 1.A.2., 1.A.4.: NO_X, CO, NMVOC, SO_2)

A3.2.1.1.a. Facilities emitting soot and smokes

1） NO_X and SO_2

- ***Methodology for Estimating Emissions***

General Survey of the Emissions of Air Pollutants by the Ministry of the Environment was used as the basis for estimation of NO_X and SO_2 emitted from fixed sources. So as to ensure consistency with the Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance (2000), the following operation isolated the emissions from the energy sector from the emissions listed in the General Survey of the Emissions of Air Pollutants:

1. All emissions from the following facilities and operations 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]

Operation: [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]

2. Emissions from the facilities and operations other than the above and [1301–1304: Waste incinerators], are reported under the Industrial Processes sector. Accordingly, the emissions from the specified sources, calculated by the following methods, are subtracted from the emissions listed in the *General Survey of the Emissions of Air Pollutants* to determine the emissions from the Energy sector.

- ***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 (to be included in the Industrial Processes sector)

NO_X emissions from metallurgical coal or coke [t- NO_X]

= NO_X emission factor per material [t- NO_X /kcal] × energy consumed per material [kcal]

× (1 – denitrification 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 (to be included in the Industrial Processes sector)
NO_X emissions from iron/ironstone or other material [t- NO_X]
= Nitrogen content per material [t- NO_X] × (1 – denitrification rate [%])

If, however, the emissions from the Industrial Processes sector calculated by the above equations exceed the emission volume 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 Industrial Processes 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_2***

Emissions from the Industrial Processes sector is calculated from the consumption and sulfur contents of the materials in categories from [41: Iron/ironstone] to [46: Other materials], and subtracted from the emissions listed in the General Survey of the Emissions of Air Pollutants to determine SO_2 emissions in the energy sector.

Calculation of SO_2 emissions (in the Industrial Processes sector)
SO_2 emissions [t-SO_2] = Sulfur content per material [t-SO_2] × (1 – desulfurization rate [%])

- ***Emission factors***

- ***NO_X emission factors for metallurgical coal and coke***

NO_X emission factors for the materials used in the calculation of NO_X emissions from metallurgical coal and coke (in the Industrial Processes sector) were established for each facility and material type based on the *General Survey of the Emissions of Air Pollutants*.

- ***Denitrification rate***

The denitrification rate was calculated by the following equation:

Calculation of denitrification rate
Denitrification rate [%]
= Denitrification efficiency [%] × (Hours of operation of denitrification unit [h/yr] /
Hours of operation of furnace [h/yr]) × (Processing capacity of denitrification unit [m^3/yr] /
max exhaust gas emission [m^3/yr])

The General Survey of the Emissions of Air Pollutants data were used for all items.

Denitrification efficiency: (NO_X volume before treatment – NO_X volume after treatment) / volume of smoke and soot

- ***Desulfurization rate***

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] /
max exhaust gas emission [m^3/yr])

The General Survey of the Emissions of Air Pollutants data were used for all items.

Desulfurization efficiency: (SO_2 volume before treatment – SO_2 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 materials]) provided in the *General Survey of the Emissions of Air Pollutants*, by the consumption volume 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 [44: Metallurgical coal] through [46:Other materials]) provided in the *General Survey of the Emissions of Air Pollutants*, by the consumption volume of the material.

2） CO

- ***Methodology for Estimating Emissions***
  Emissions of CO from the specified sources were calculated by multiplying the energy consumption per facility type by Japan's own emission factor.

- ***Emission factors***
  CO emission factors were established based on the summary data in the *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996).

- ***Activity data***
  Energy consumption according to facility type determined from *General Energy Statistics* was used for activity data.

3） NMVOC

- ***Methodology for Estimating Emissions***
  Emissions of NMVOC from the specified sources were calculated by multiplying the energy consumption per facility type by Japan's own emission factor.

- ***Emission factors***
  NMVOC emission factors were established by multiplying the CH_4 emission factor for each facility per fuel type by the ratio of NMVOC emission to CH_4 emission factor per fuel type. The CH_4 emission factors were established from the summary data provided in the *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996), while the NMVOC/CH_4 emission factor 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 according to facility type determined from *General Energy Statistics* (Agency for Natural Resources and Energy) was used for activity data.

A3.2.1.1.b. Small facilities (commercial and other sector, manufacturing sector)

- ***Methodology for Estimating Emissions***

  NO_X, CO, NMVOC, and SO_2 emitted by the specified sources were calculated by multiplying energy consumption per facility type by Japan's own emission factor.

- ***Emission factors***

➢ ***NO_X and SO_2***

Emission factors for NO_X and SO_2 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 per fuel type.

➢ ***CO***

The emission factors established for [0102: Heating system boilers] based on the *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996) were adopted as the CO emission factors.

➢ ***NMVOC***

NMVOC emission factors were established by multiplying the CH_4 emission factors for [0102: Heating system boilers] by the ratio of NMVOC emission to CH_4 emission factor per fuel type. The CH_4 emission factors were established from the *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996), while the NMVOC/CH_4 emission factor 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***

  To determine NO_X and SO_2, energy consumption by small facilities per fuel type was calculated by subtracting energy consumption per fuel type, identified by the *General Survey of the Emissions of Air Pollutants*, from energy consumption per 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 heating oil A. Energy consumption from *General Energy Statistics* (Agency for Natural Resources and Energy) was used for CO and NMVOCs.

A3.2.1.1.c. Residential sector

- ***Methodology for Estimating Emissions***

  NO_X, CO, NMVOC, and SO_2 emissions from the target source were calculated by multiplying energy consumed per facility type by Japan's own emission factor or the IPCC default emission factor.

- ***Emission factors***

➢ ***NO_X***

For solid fuels (steaming coal and coal briquettes), emission factors were established by converting the default values provided in the Revised 1996 IPCC Guidelines to gross calorific values.

For liquid (kerosene) and gaseous (LPG, town gas) fuels, the emission factors per usage per fuel type provided in the reports by Air Quality Management Bureau, Ministry of the Environment (Reference #20) were used. This report calculated the emission factors by weighting the average concentration of NO_X emissions per source unit, obtained through questionnaires and interviews in the household gas appliances industry.

➢ ***CO***

For solid fuels (steaming coal and coal briquettes), emission factors were established by converting the default values provided in the Revised 1996 IPCC Guidelines to gross calorific values.

For liquid (kerosene) and gaseous (LPG, town gas) fuels, the emission factors per usage per fuel type provided in the reports by Institute of Behavioral Science (Reference #25) were used. This report tabulated the emission factors by usage and fuel using the actual values measured in Tokyo, Yokohama city and Chiba Prefecture.

➢ ***NMVOC***

For all of the solid (steaming coal and coal briquettes), liquid (kerosene), and gaseous (LPG and town gas) fuels, emission factors were established by converting the default values provided in the *Revised 1996 IPCC Guidelines* to gross calorific values.

➢ ***SO_2***

For solid fuels (steaming coal and coal briquettes), emission factors were established by converting the default values provided in the Revised 1996 IPCC Guidelines 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***

Consumption by type of fuel for residential use in *General Energy Statistics* has been taken for the activity data. The fuels covered were steaming coal, coal briquettes, kerosene, LPG, and town gas. For the amount of residential fuel consumption by type of use, the ratio of consumption by energy source and by type of use per household, in the *Handbook of Energy & Economic Statistics in Japan* (The Energy Data and Modeling Center) is used.

A3.2.1.1.d. Incineration of waste for energy purposes and with energy recovery

Emissions of NO_X, CO, NMVOC and SO_2 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 Fuels" under the relevant subcategories of 1.A.1 and 1.A.2. Explanations for methodology for estimating emissions, emission factors, and activity data are all given in the section "A3.1.6. Wastes".

A3.2.1.2. Mobile Combustion (1.A.3: NO_X, CO, NMVOC, and SO_2)

A3.2.1.2.a. Road Transportation (1.A.3.b.)

1） NO_X, CO, and NMVOC

● ***Methodology for Estimating Emissions***

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 own 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) (per Ministry of the Environment) by the percentage of NMVOC in the THC emission (per Ministry of the Environment).

Table A 3-16 NO_X emission factors for automobiles

Fuel	Vehicle type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light vehicle	g-NOx/km	0.230	0.159	0.157	0.079	0.045	0.035	0.027	0.020	0.016
	Passenger vehicle (including LPG)	g-NOx/km	0.237	0.203	0.199	0.080	0.047	0.037	0.028	0.021	0.016
	Light cargo truck	g-NOx/km	0.873	0.658	0.375	0.200	0.128	0.106	0.089	0.076	0.066
	Small cargo truck	g-NOx/km	1.115	0.897	0.478	0.087	0.042	0.032	0.025	0.020	0.016
	Regular cargo truck	g-NOx/km	1.833	1.093	0.560	0.162	0.061	0.043	0.032	0.026	0.022
	Bus	g-NOx/km	4.449	3.652	2.438	0.090	0.052	0.040	0.034	0.030	0.026
	Special-purpose vehicle	g-NOx/km	1.471	0.873	0.429	0.121	0.052	0.037	0.029	0.024	0.020
Diesel	Passenger vehicle	g-NOx/km	0.636	0.526	0.437	0.448	0.384	0.361	0.339	0.312	0.279
	Small cargo truck	g-NOx/km	1.326	1.104	1.005	1.009	0.829	0.744	0.658	0.580	0.506
	Regular cargo truck	g-NOx/km	5.352	4.586	4.334	4.497	4.028	3.759	3.422	3.115	2.788
	Bus	g-NOx/km	4.226	3.830	3.597	4.070	3.502	3.212	2.880	2.615	2.378
	Special-purpose vehicle	g-NOx/km	3.377	2.761	2.152	3.626	3.164	2.923	2.633	2.381	2.129

Source: Ministry of the Environment

Table A 3-17 CO emission factors for automobiles

Fuel	Vehicle Type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light vehicle	g-CO/km	1.749	1.549	1.543	0.971	0.692	0.607	0.537	0.483	0.444
	Passenger vehicle (including LPG)	g-CO/km	2.325	2.062	2.034	0.936	0.667	0.582	0.509	0.452	0.411
	Light cargo truck	g-CO/km	10.420	8.540	5.508	2.773	2.032	1.887	1.787	1.729	1.691
	Small cargo truck	g-CO/km	9.656	10.079	8.309	2.075	1.013	0.785	0.607	0.475	0.380
	Regular cargo truck	g-CO/km	12.624	10.601	8.950	3.616	1.601	1.208	0.941	0.796	0.683
	Bus	g-CO/km	26.209	25.079	21.938	2.072	1.320	1.140	1.066	0.976	0.928
	Special-purpose vehicle	g-CO/km	12.466	10.666	8.924	2.298	1.138	0.886	0.746	0.656	0.580
Diesel	Passenger vehicle	g-CO/km	0.480	0.432	0.429	0.374	0.317	0.288	0.258	0.224	0.192
	Small cargo truck	g-CO/km	0.975	0.896	0.808	0.601	0.413	0.343	0.284	0.240	0.204
	Regular cargo truck	g-CO/km	3.221	2.988	2.440	2.042	1.437	1.205	0.995	0.829	0.670
	Bus	g-CO/km	2.579	2.534	2.200	2.035	1.386	1.131	0.913	0.761	0.638
	Special vehicle	g-CO/km	2.109	1.893	1.297	1.601	1.075	0.881	0.713	0.592	0.479

Source: Ministry of the Environment

Table A 3-18 NMVOC emission factors for automobiles

Fuel	Vehicle Type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	Light Vehicle	g-HC/km	0.128	0.050	0.048	0.043	0.027	0.023	0.019	0.017	0.014
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.077	0.030	0.029	0.026	0.016	0.014	0.012	0.010	0.009
	Passenger Vehicle (including LPG)	g-HC/km	0.189	0.112	0.104	0.030	0.020	0.017	0.015	0.012	0.011
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.113	0.067	0.062	0.018	0.012	0.010	0.009	0.007	0.006
	Light Cargo Truck	g-HC/km	1.058	0.610	0.274	0.151	0.096	0.079	0.066	0.057	0.050
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.635	0.366	0.165	0.091	0.058	0.048	0.040	0.034	0.030
	Small Cargo Truck	g-HC/km	1.188	0.882	0.346	0.068	0.030	0.022	0.017	0.013	0.010
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.713	0.529	0.208	0.041	0.018	0.013	0.010	0.008	0.006
	Regular Cargo Truck	g-HC/km	1.658	0.959	0.471	0.103	0.043	0.029	0.020	0.016	0.013
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.995	0.575	0.283	0.062	0.026	0.018	0.012	0.010	0.008
	Bus	g-HC/km	3.604	3.164	2.193	0.065	0.029	0.023	0.020	0.017	0.015
		%	60%	60%	60%	60%	60%	60%	60%	160%	160%
		g-NMVOC/km	2.162	1.899	1.316	0.039	0.017	0.014	0.012	0.027	0.024
	Special Vehicle	g-HC/km	1.619	0.786	0.317	0.081	0.035	0.025	0.020	0.017	0.014
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.972	0.472	0.190	0.048	0.021	0.015	0.012	0.010	0.009
Diesel	Passenger Vehicle	g-HC/km	0.109	0.098	0.097	0.089	0.078	0.072	0.066	0.059	0.052
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.065	0.059	0.058	0.053	0.047	0.043	0.040	0.036	0.031
	Small Cargo Truck	g-HC/km	0.389	0.343	0.258	0.206	0.119	0.090	0.067	0.050	0.037
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.233	0.206	0.155	0.124	0.071	0.054	0.040	0.030	0.022
	Regular Cargo Truck	g-HC/km	1.634	1.488	1.040	0.753	0.488	0.394	0.315	0.254	0.200
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.980	0.893	0.624	0.452	0.293	0.237	0.189	0.153	0.120
	Bus	g-HC/km	1.273	1.255	0.995	0.807	0.495	0.381	0.291	0.233	0.189
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.764	0.753	0.597	0.484	0.297	0.229	0.175	0.140	0.113
	Special Vehicle	g-HC/km	1.101	0.965	0.526	0.575	0.350	0.276	0.216	0.174	0.138
		%	60%	60%	60%	60%	60%	60%	60%	60%	60%
		g-NMVOC/km	0.661	0.579	0.316	0.345	0.210	0.165	0.129	0.105	0.083

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***

  The activity data used the travel distance per year for each vehicle class per fuel type, which were calculated by multiplying distances traveled in a year for each vehicle class per fuel type, provided in the *Statistical Yearbook of Motor Vehicle Transport* (Ministry of Land, Infrastructure, Transport and Tourism), by the percentage of the distances per fuel types calculated from fuel consumption and cost data.

2） SO_2

- ***Methodology for Estimating Emissions***

  The emissions of SO_2 from these sources were calculated by multiplying fuel consumption by vehicle class and fuel types by Japan's own emission factor.

- ***Emission factor***

  Sulfur content (by weight) of each fuel type was used to establish emission factors.

Table A 3-19 Sulfur content (by weight) by fuel type

Fuel	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Gasoline	%	0.008%	0.008%	0.008%	0.008%	0.008%	0.008%	0.008%	0.008%	0.008%
Diesel	%	0.350%	0.136%	0.136%	0.136%	0.136%	0.136%	0.136%	0.136%	0.136%
LPG	%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%	0.002%

Source: Gasoline/LPG – The Institute of Behavioral Science, Diesel oil – Petroleum Association of Japan

- ***Activity data***

  Activity data was calculated by multiplying fuel consumption for each vehicle class per fuel type by specific gravity of each fuel type, and converting the resultant values to weight. The fuel consumption data was reported in the *Statistical Yearbook of Motor Vehicle Transport* (Ministry of Land, Infrastructure, Transport and Tourism).

- ***Completeness***

  Emissions of NO_X, CO, NMVOCs, and SO_2 from natural gas vehicles and motorcycles are reported as "NE".

A3.2.1.2.b. Civil Aviation (1.A.3.a: NO_X, CO, NMVOC)

- ***Methodology for Estimating Emissions***

  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 *Revised 1996 IPCC Guidelines*.

- ***Emission factors***

  The default emission factors provided for the "Jet and Turboprop Aircraft" category in the *Revised 1996 IPCC Guidelines* were used.

Table A 3-20 IPCC default emission factors for civil aviation

Gas	EF [g/MJ]
NO_X	0.29
CO	0.12
NMVOC	0.018

Source: *Revised 1996 IPCC Guidelines*, Vol. 3; Page 1.90, Table 1-47

- ***Activity data***

  Figures for jet fuel consumption (for domestic scheduled flights and others [commuter, sightseeing and charter flights]) in the *Statistical Yearbook of Air Transport* (Ministry of Land, Infrastructure, Transport and Tourism) were converted to net calorific value for the calculation of activity data.

- ***Completeness***

  Emissions of NO_X, CO, and NMVOCs from aviation fuel consumption are reported as "NE".

A3.2.1.2.c. Navigation (1.A.3.d.: NO_X, CO, NMVOC)

1） NO_X, CO, and NMVOC

- ***Methodology for Estimating Emissions***

  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 for the "Ocean-Going Ships" category in the *Revised 1996 IPCC Guidelines* were used.

Table A 3-21 IPCC default emission factors for ocean-going ships

Gas	Emission factor [g/MJ]
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 per fuel type (diesel, heating oil A, heating oil B, and heating oil C) provided in the *General Energy Statistics* (Agency for Natural Resources and Energy) were converted to net calorific value for the calculation of activity data. The consumption data were based on the statistical data on marine transport (coastal services [passenger and freight]) in the *The Survey on Transport Energy* (Ministry of Land, Infrastructure, Transport and Tourism).

2） SO_2

- ***Methodology for Estimating Emissions***

  Emissions from the specified sources were calculated by multiplying the fuel consumption by the emission factors.

- ***Emission factors***

  The multiplied product of the specific gravity of each marine fuel, the sulfur ratio of each fuel, and the molecular weight ratio of sulfur dioxide versus sulfur is used for the emission factor. The sulfur ratio of each fuel is restricted by law or Japanese Industrial Standard, therefore the regulation value is used for the sulfur ratio in the estimation.

Table A 3-22 Specific gravity and sulfur ratio of fuel for ocean-going ships

Fuel	Specific Gravity [kg/l]	Sulfur Ratio [% in weight]
Diesel Oil	0.83	0.001
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 Act on the Quality Control of Gasoline and Other Fuels

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 per fuel type (diesel, heating oil A, heating oil B, and heating oil C) provided in the *General Energy Statistics* (Agency for Natural Resources and Energy) were used for the activity data. The consumption data were based on the statistical data on marine transport (coastal services [passenger and freight]) in the *The Survey on Transport Energy* (Ministry of Land, Infrastructure, Transport and Tourism).

A3.2.1.2.d. Railways (1.A.3.c.: NO_X, CO, and NMVOC)

- ***Methodology for Estimating Emissions***

  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 3-23 IPCC default emission factors for locomotives

Gas	Emission factor [g/MJ]
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 for the calculation of activity data.

A3.2.1.3. Fugitive emissions from fuels (1.B.: NMVOC)

A3.2.1.3.a. NMVOCs fugitive emissions at oil refinery

- ***Methodology for Estimating Emissions***

  NMVOC emissions from the specified sources were calculated by multiplying the capacity of oil refineries (BPSD: Barrels Per Stream Day) by Japan's own emission factors and annual days of operation.

- ***Emission factor***

  Based on the *Study on the total system for prevention of HC-Vapor in petroleum industries* (Agency of Natural Resources and Energy, 1975), the emission factor was established as 0.05767 (g-NMVOC/BPSD). The number of days of operation for atmospheric distillation was established as 350 days.

- ***Activity data***

  Figures for the BPSD based on the results of surveys conducted by the Ministry of Economy, Trade and Industry, were used for the calculation of activity data.

A3.2.1.3.b. NMVOCs emissions from lubricant oil production

- ***Methodology for Estimating Emissions***

  NMVOC emissions from the specified sources were calculated by multiplying gross sales amount to consumers by Japan's own emission factors for toluene and methyl ethyl ketone.

- ***Emission factors***

  Based on internal documents of Yokohama city, emission factors were established for toluene and methyl ethyl ketone.

Table A 3-24 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: Yokohama city

- ***Activity data***

  Figures for gross sales amount to consumers, provided in the *Yearbook of Mineral Resources and Petroleum Production Statistics* (Ministry of Economy, Trade and Industry), were used for the calculation of activity data.

A3.2.1.3.c. NMVOCs fugitive emissions at storage facilities

- ***Methodology for Estimating Emissions***

  NMVOC emissions from the specified sources were calculated on the assumption that yearly emissions were the same as the 1983 volume of losses from breathing and acceptance for cone-roof type storage tanks and shipping losses from floating-roof type storage tanks at refineries and storage tanks (Petroleum Association of Japan).

- ***Emission factor***

  No emission factors were established.

- ***Activity data***

  No activity data were used.

A3.2.1.3.d. NMVOCs fugitive emissions at shipping facilities

- ***Methodology for Estimating Emissions***

  NMVOC emissions from specified sources were calculated by multiplying the 1983 figures for NMVOC emissions from ships and tank lorries/freight cars by the 1983 ratio of amount of shipment or that of sales to consumers.

- ***Emission factor***

  No emission factors were established.

- ***Activity data***

  Figures for shipment of crude oil not to be refined, gross sales amount of gasoline to consumers, export of gasoline, gross sales amount of naphtha to consumers, export of naphtha, gross sales amount of jet fuel to consumers and export of jet fuel 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. Table A 3-25 shows the relationship between the NMVOC emission sources and activity data.

Table A 3-25 Relationship between emission sources and activity data

NMVOC emission source		Activity data used in calculation
Ships	Crude oil	shipment of crude oil not to be refined
	Gasoline	gross sales amount of gasoline to consumers
		export of gasoline
	Naphtha	gross sales amount of naphtha to consumers
		export of naphtha
	Jet fuel	gross sales amount of jet fuel to consumers
		export of jet fuel
Tank lorries /Freight cars	Gasoline	gross sales amount of gasoline to consumers
	Naphtha	gross sales amount of naphtha to consumers
	Jet fuel	gross sales amount of jet fuel to consumers

A3.2.1.3.e. NMVOCs fugitive emissions from gas stations

- ***Methodology for Estimating Emissions***

NMVOC emissions from specified sources were calculated by multiplying amount of sales to consumers by Japan's own emission factors for oil accepting and providing, and subtracting the portion of fuels prevented from fugitive emissions by a vapor return facility.

- ***Emission factor***

Emission factors were established for oil accepting and for oil providing, based on the *Study on the total system for prevention of HC-Vapor in petroleum industries* (Agency of Natural Resources and Energy, 1975).

Table A 3-26 Emission factors at gas stations during oil accepting and providing

	Emission factor [kg/kl]
Oil accepting	1.08
Oil providing	1.44

Source: Study on the total system for prevention of HC-Vapor in petroleum industries (Agency of Natural Resources and Energy, 1975)

- ***Activity data***

Figures for sales amount of gasoline (for automobiles) in the Yearbook of Mineral Resources and Petroleum Products Statistics (Ministry of Economy, Trade and Industry) were used for the calculation of activity data.

Fugitive emissions prevented by a vapor return facility during oil accepting at gas stations were calculated by the following equation:

Calculation of fugitive emissions prevented by vapor return facility during oil accepting

Fugitive emissions prevented by vapor return facility during oil accepting [t]

= ΣPrefecture {(gasoline sales per prefecture [ML] × emission factor for oil accepting [kg/kl])

× (No. of service stations with vapor return facility per prefecture

/ No. of service stations per prefecture)}

Based on the data provided in the *Yearbook of Mineral Resources and Petroleum Products Statistics* (Ministry of Economy, Trade and Industry). For the number of service stations after FY2001, the number of service stations registered under law was used.

A3.2.2. Industrial Processes

A3.2.2.1. Mineral Products, Chemical Industry, Metal Production, and Other Production (2.A., 2.B., 2.C., 2.D.,: NO_X, SO_2)

- ***Methodology for Estimating Emissions***

NO_X and SO_2 emissions from the specified sources were calculated for sources not included in the following facilities or operations by isolating the emissions from the Industrial Processes sector.

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]

Operation: [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 Industrial Processes sector)

NO_X emissions from metallurgical coal or coke [t-NO_X]

= NO_X emission factor per origin [t- NO_X /kcal] × energy consumed per material [kcal]

× (1 – denitrification 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 Industrial Processes sector)

NO_X emissions from iron/iron ore or other material [t-NO_X]

= Nitrogen content per material [t-NO_X] × (1 – denitrification rate [%])

If, however, the emissions from the Industrial Processes sector calculated by the above equations exceed the emission volume 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 Industrial Processes 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_2***

Based on the consumption and sulfur contents of the materials in the categories from [41: Iron/ironstone] to [46: Other materials], SO_2 emissions from the Industrial Processes sector are calculated as follows:

Calculation of SO_2 emissions (in the Industrial Processes sector)

SO_2 emissions [t-SO_2]

= Sulfur content per material [t-SO_2] × (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 Industrial Processes sector) were established for each facility and material type based on the *General Survey of the Emissions of Air Pollutants*.

➢ ***Denitrification rate***

The denitrification rate was calculated by the following equation:

Calculation of denitrification rate
Denitrification rate [%]
= Denitrification efficiency [%] × (Hours of operation of denitrification unit [h/yr]
/ Hours of operation of furnace [h/yr]) × (Processing capacity of denitrification unit [m^3/yr]
/ max. exhaust gas emission [m^3/yr])

The General Survey of the Emissions of Air Pollutants data were used for all items.

Denitrification 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]
/ max. exhaust gas emission [m^3/yr])

The General Survey of the Emissions of Air Pollutants data were used for all items.

Desulfurization efficiency: (SO_2 volume before treatment – SO_2 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 volume 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 volume of the material.

A3.2.2.2. Other (2.G.: NMVOC)

A3.2.2.2.a. NMVOCs emissions from petrochemical manufacturing

● ***Methodology for Estimating Emissions***

NMVOCs emissions from petrochemical manufacturing were calculated by multiplying the production volume per type of petrochemical product by Japan’s own emission factors.

- ***Emission factors***

  Emission factors were established based on the *Basic Study on HC Sources* (Institute of Behavioral Science, 1987).

Table A 3-27 NMVOC emission factors by petrochemical product

Petrochemical product	Emission factor [kg/t]
Propylene oxide	0.828
Vinyl chloride monomer	3.288
Styrene monomer	0.529
Vinyl acetate	1.299
B.T.X.	0.080
Ethylene oxide	0.421
Acrylonitrile	1.035
Butadiene	0.210
Polyethylene (produced under middle-low pressure)	1.851
Polyethylene (produced under high pressure)	1.088
ABS, AS resins	1.472
Synthetic rubber	0.248
Acetaldehyde	0.016
Terephthalic acid	0.534
Polypropylene	2.423
Ethylene and Propylene	0.016

Source: Basic Study on HC Sources (Institute of Behavioral Science, 1987).

- ***Activity data***

  Figures in the petrochemical production volume by type in the *Yearbook of Mineral Resources and Petroleum Products Statistics* (Ministry of Economy, Trade and Industry) were used for the calculation of activity data.

A3.2.2.2.b. NMVOCs emissions from storage facilities for chemical products

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from storage facilities for chemical products were calculated on the assumption that the emission volumes were same as the 1983 combined yearly emissions of “Petrochemicals” and “Others”, given in the *Basic Study on HC Sources* (Institute of Behavioral Science, 1987). “Petrochemicals” covered base chemicals (for the chemical industry); “Other” covered solvents (shipped primarily for non-feedstock use).

- ***Emission factors***

  No emission factors were established.

- ***Activity data***

  No activity data were calculated.

A3.2.2.2.c. NMVOCs emissions from shipping facilities for chemical products

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from shipping facilities for chemical products were calculated on the assumption that the emission volumes were same as the 1983 combined yearly emissions of “Petrochemicals” and “Others”, shown in the *Basic Study on HC Sources* (Institute of Behavioral Science, 1987). “Petrochemicals” covered base chemicals (for the chemical industry); “Other” covered solvents (shipped primarily for non-feedstock use).

- ***Emission factors***

  No emission factor has been established.

- ***Activity data***

  No activity data has been established.

A3.2.3. Sectors that use solvents and other products

A3.2.3.1. NMVOCs emissions from paint solvent use (3.A.: NMVOC)

- ***Methodology for Estimating Emissions***

  Emissions of NMVOC were calculated by multiplying the consumption of solvent by the NMVOC emission rate (the percentage of NMVOC not removed but released into atmosphere).

- ***Emission factors***

  The NMVOC emission rate (92.54[%] = 100[%] – 7.46[%]) calculated from the NMVOC removal rate (7.46[%]) estimated by the Ministry of the Environment (1983) was used as the emission factor.

- ***Activity data***

  Consumption of solvent was calculated by multiplying the 1990 data for solvent consumption per solvent type by the 1990 ratio of solvent consumption in paint production. The consumption data were extracted from the Present condition and prospect about VOCs in Paint Industry (Japan Paint Manufacturers Association). The solvent consumption ratio was provided in the Yearbook of Chemical Industries Statistics (Ministry of Economy, Trade and Industry). As the statistical records on solvent consumption in paint production were discontinued, the data for 2001 were substituted for values for years 2002 and beyond.

Calculation of annual consumption of paint solvent A in Year X

Annual consumption of paint solvent A in Year X [t]

＝Annual consumption of paint solvent A in 1990 [t]

×(Annual consumption of paint production solvent B in Year X [t]

/Annual consumption of paint production solvent B in 1990 [t])

Table A 3-28 Relationship of types of paint solvents and solvents for paint production used in calculation

Types of Paint Solvent (A)	Types of Paint Production Solvents Used in Calculation (B)
Aliphatic compound hydrocarbon	Mineral spirit
Alicyclic compound hydrocarbon	Toluene, xylene, and other aromatic hydrocarbon
Aromatic compound hydrocarbon	Toluene, xylene, and other aromatic hydrocarbon
Petroleum mixed solvent	Mineral spirit
Alcohol solvent	Alcohol solvent
Ether, Ether Alcohol solvent	Alcohol solvent
Ester solvent	Ester solvent
Ketone solvent	Ketone solvent
Chloric solvent	Solvent with a high boiling point
Other non-chloric solvent	Solvent with a high boiling point

A3.2.3.2. Degreasing, dry cleaning (3.B.: NMVOC)

A3.2.3.2.a. NMVOCs emissions from metal cleansing

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from metal cleansing were calculated by multiplying the shipping amount of solvents (trichloro ethylene and tetrachloro ethylene) in degreasing by Japan's own emission factor.

- ***Emission factors***

  Emission factors were established as the ratio of emission to shipment (0.66 [Mg/t] = 88,014 / 133,000), based on data for 1983 in the *Report on the Survey of Measures for Stationary Sources of Hydrocarbons* (Institute of Behavioral Science, 1991).

- ***Activity data***

  Shipping amount of solvents was calculated by multiplying the sales volume of trichloro ethylene and tetrachloro ethylene, provided in the *Yearbook of Chemical Industries Statistics* (Ministry of Economy, Trade and Industry), by the ratio of consumption for metal cleansing use to total consumption of organic chloric solvent (3 type) (0.2 = 11,266 / 56,350), shown in documents from the Perchlo Association.

A3.2.3.2.b. NMVOCs emissions from dry cleaning

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from dry cleaning were calculated on the assumption that the volume of NMVOC emissions was the same as the volume of solvents used in dry cleaning (petroleum solvents and tetrachloro ethylene).

- ***Emission factors***

  No emission factors were established, as all the solvents used in dry cleaning were assumed to be discharged into the atmosphere.

- ***Activity data***

  Estimates by the Institute of Cleaning Research were used for the calculation of the annual consumption of petroleum solvents and tetrachloro ethylene in 1990 and 1991.

  Annual consumption in 1992 and in subsequent years was calculated by the following equation on the assumption that solvent consumption was proportional to the number of machines in operation:

> *Calculation of annual consumption of solvents in Year X*
>
> Annual consumption of solvents in Year X [t]
>
> = Σpetroleum-based solvent/tetrachloroethylene {annual consumption of petroleum solvents or tetrachloroethylene in 1991 [t] × (the number of machines in operation in Year X / the number of machines in operation in 1991)}

A3.2.3.3. Chemical products, manufacture and processing (3.C.: NMVOC)

A3.2.3.3.a. NMVOCs emissions from paint production

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from paint production were calculated by multiplying the amount of solvent treated in paint production by Japan's own emission factors.

- ***Emission factors***

  Emission factors were established based on the *Manual to control HC emissions* (Air Quality Management Bureau, Ministry of the Environment, 1982).

Table A 3-29 Emission factors for solvents used as raw material for paints

Solvent	Emission factor [%]
Toluene	0.3
Xylene	0.2
Other aromatic hydrocarbon	0.2
Mineral spirit	0.2
Alcohol solvent	0.3
Ester solvent	0.3
Methyl isobutyl ketone	0.3
Other ketones	0.2
Solvent with a high boiling point	0.1

Source: Manual to control HC emissions (Air Quality Management Bureau, Ministry of the Environment, 1982)

- ***Activity data***

  Amount of solvent treated in paint production in the *Yearbook of Chemical Industries Statistics* (Ministry of Economy, Trade and Industry) was used for the calculation of activity data. The usage of ketone solvents was allocated to “Methyl isobutyl ketone” and “Other ketones” (with approx. 63% allocated to methyl isobutyl ketones), based on the interview survey results included in *Manual to control HC emissions* (Air Quality Management Bureau, Ministry of the Environment, 1982). For 2002 and subsequent years, the 2001 values were used because the statistics were discontinued.

A3.2.3.3.b. NMVOCs emissions from printing ink production

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from printing ink production were calculated by multiplying amount of solvent treated in paint production, by Japan’s own emission factors.

- ***Emission factors***

  Emission factors were established based on the results of surveys conducted by the Ministry of the Environment, as well as *Basic study on HC sources* (Institute of Behavioral Science, 1987).

Table A 3-30 Emission factors for solvents used as raw materials for printing ink

Solvent	Emission factor
Petroleum solvent [a)]	0.00033
Aromatics hydrocarbon [a)]	0.00108
Alcohol solvent [a)]	0.00105
Ester, ether solvent [b)]	0.00117

Source: a: Surveys by the Ministry of the Environment

b: Basic Study on HC sources (Institute of Behavioral Science, 1987) Activity data

- ***Activity data***

  Amount of solvent treated in paint production in the Yearbook of Chemical Industries Statistics (Ministry of Economy, Trade and Industry) were used for the calculation of activity data. For 2002 and subsequent years, the 2001 values were used because the statistics were discontinued.

A3.2.3.3.c. NMVOCs emissions from printing ink solvent use

- ***Methodology for Estimating Emissions***
  NMVOCs emissions from printing ink solvent use were calculated by multiplying the 1983 figures for NMVOC emissions from printing ink solvent use by the ratio of 1983 and each year about shipment amount of solvent.

- ***Emission factor***
  Emission factors were established as “0.3”.

- ***Activity data***
  Shipment amount of solvent in the *Yearbook of Chemical Industries Statistics* (Ministry of Economy, Trade and Industry) were used for the calculation of activity data.

A3.2.3.3.d. NMVOCs emissions from polyethylene laminate

- ***Methodology for Estimating Emissions***
  NMVOCs emissions from polyethylene laminate were calculated on the assumption that the yearly emissions equaled the 1983 emissions data provided in the *Basic study on HC sources* (Institute of Behavioral Science, 1987)

- ***Emission factor***
  No emission factors were established.

- ***Activity data***
  No activity data were calculated.

A3.2.3.3.e. NMVOCs emissions from solvent-type adhesive use

- ***Methodology for Estimating Emissions***
  NMVOCs emissions from solvent-type adhesive use were assumed to equal the amount of solvents (xylene, toluene) used in adhesives.

- ***Emission factors***
  No emission factors were established as all the solvents used in adhesives were assumed to be discharged into the atmosphere.

- ***Activity data***
  Shipment amount of adhesive were calculated by multiplying amount of adhesives shipment by type (on calendar year basis), shown in the *Current survey report on adhesive* (Japan Adhesive Industry Association), by solvent content rate for each type shown in the *Current survey report on adhesive* (Japan Adhesive Industry Association).

Table A 3-31 Solvent content in adhesives by type

Adhesive	Solvent content [%]
Vinyl acetate resin solvent type	65
Other resin solvent type	50
CR solvent type	71
Other synthetic rubber solvent type	76
Natural rubber solvent type	67

Source: Current survey report on adhesive (Japan Adhesive Industry Association)

A3.2.3.3.f. NMVOCs emissions from gum solvent use

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from gum solvent use were calculated by multiplying the consumption of solvents in rubber by NMVOC emission rate (the percentage of NMVOC not removed but released into atmosphere).

- ***Emission factors***

  The NMVOC emission rate (92.7[%] = 100[%] – 7.3[%]) was used. This was calculated from the 1983 estimate of the NMVOC removal rate (7.3%), provided in the *Basic study on HC sources* (Institute of Behavioral Science, 1987).

- ***Activity data***

  The annual consumption of solvents in rubber was calculated by multiplying the consumption of petrol for solvent use by the ratio of the amount of rubber petrol use to total amount of gum solvent use (0.42 = 21,139 / 50,641). The consumption data were obtained either from the *Statistics of rubber products* (Ministry of Economy, Trade and Industry) or the results of surveys by the Japan Rubber Manufacturers Association; the usage rate was provided by the *Basic study on HC sources* (Institute of Behavioral Science, 1987).

A3.2.3.4. Other (3.D.: NMVOC)

A3.2.3.4.a. NMVOCs emissions from other solvent use for production

- ***Methodology for Estimating Emissions***

  NMVOCs emissions from other solvent use for production were calculated on the assumption that the yearly emissions equaled the 1983 emissions shown in the *Basic study on HC sources* (Institute of Behavioral Science, 1987).

- ***Emission factor***

  No emission factors were established.

- ***Activity data***

  No activity data were calculated.

A3.2.4. Agriculture

A3.2.4.1. Field burning of agricultural residues (4.F.)

A3.2.4.1.a. Rice Straw, Rice Chaff & Straw of Wheat, Barley, Oats and Rye (4.F.1.: CO)

- ***Methodology for Estimating Emissions***

  CO emissions from the specified sources were calculated by using Japan's own Methodology for Estimating Emissions shown below (Rye and oats were excluded from the estimate because there are no Japan-specific emission factors for them):

Calculation of CO emission from burning of rice straw, chaff, and wheat straw
CO emission from burning of rice and wheat straw and chaff [t-CH_4]
= $\Sigma_{\text{rice straw, wheat straw, chaff}}$ (amount of rice or wheat straw or chaff burnt [t]
× carbon content (dry weight) × percentage of carbon released as CO
× mol ratio of CO to CO_2 in emitted gases)

- ***Emission factors***

Emission factors were established for each parameter based on the measured data available in Japan.

Table A 3-32 Carbon content of rice/wheat straw and chaff

	Carbon content	Note
Rice straw	0.356	Adopted the mean value between 0.369[a] and 0.342[b].
Chaff	0.344	Value measured by Bando et al.[a]
Wheat straw	0.356	Assumed to be the same as for rice straw

Source: a: Bando, Sakamaki, Moritomi, and Suzuki, "*Study of analysis of emissions from biomass burning*" (from the 1991 Report on Studies on Comprehensive Promotion Cost of Environmental Studies (National Institute of Environmental Studies, 1992))

b: Y Miura and T Kanno, "Emissions of trace gases (CO_2, CO, CH_4, and N_2O) resulting from rice straw burning", Soil Sci. Plant Nutr., 43(4),849–854, 1997

Table A 3-33 Percentage of carbon emitted as CO from rice and wheat straw and chaff

	Percentage of carbon emitted as CO	Note
Rice straw	0.684	Adopted the median value between 0.8[a] and 0.567[b].
Chaff	0.8	Value measured by Bando et al.[a]
Wheat straw	0.684	Assumed to be the same as for rice straw

Source: a: Bando, Sakamaki, Moritomi, and Suzuki, "*Study of analysis of emissions from biomass burning*" (from the 1991 Report on Studies on Comprehensive Promotion Cost of Environmental Studies (National Institute of Environmental Studies, 1992))

b: Y Miura and T Kanno, "Emissions of trace gases (CO_2, CO, CH_4, and N_2O) resulting from rice straw burning", Soil Sci. Plant Nutr., 43(4),849–854, 1997

Table A 3-34 Mol ratio of CO to CO_2 in gases emitted from burning rice and wheat straw and chaff

	Mol ratio of CO to CO_2 in emitted gas	Note
Rice straw	0.219	Adopted the mean value between values by a and b.
Chaff	0.255	Value measured by Bando et al.[a]
Wheat straw	0.219	Assumed to be the same as for rice straw

Source: a: Bando, Sakamaki, Moritomi, and Suzuki, "*Study of analysis of emissions from biomass burning*" (from the 1991 Report on Studies on Comprehensive Promotion Cost of Environmental Studies (National Institute of Environmental Studies, 1992))

b: Y Miura and T Kanno, "Emissions of trace gases (CO_2, CO, CH_4, and N_2O) resulting from rice straw burning", Soil Sci. Plant Nutr., 43(4),849–854, 1997

- ***Activity data***

Amounts of rice straw, chaff, and wheat straw burned were drawn from amounts used in 4.F.1. to calculate CH_4 and N_2O emissions from the burning of agricultural residue. Amounts of wheat straw burned were obtained by using the following equation.

Amount of wheat/barley straw burned = (amounts of wheat and barley burned) × 0.5

Note: Based on expert judgment, the ratio of straw to chaff was set at 1:1.

A3.2.5. Land Use, Land-Use Change and Forestry

A3.2.5.1. Biomass burning (5(V))

- ***Methodology for Estimating Emissions***

For CO and NO_X emissions due to biomass burning, Tier 1 method is used.

➢ ***Forest land***

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 in Forest land, carbon released by forest fire is used. For detailed information, see the description on the activity data in section 7.14 in Chapter 7.

A3.2.6. Wastes

A3.2.6.1. Waste incineration (6.C.)

A3.2.6.1.a. Municipal Solid Waste Incineration (6.C.–)

- ***Methodology for Estimating Emissions***

The NO_X, CO, NMVOC, and SO_2 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 own emission factors. These emissions are categorized following the methods given in chapter 8 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_2***

For incinerators, emission factors were established for each incinerator type by using the emission volume and volume 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 should be 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 3-35 NO_X and SO_2 emission factors for municipal waste incineration by facility type

	Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
NOx	Continuous Incinerator	kg-NOx/t	1.238	1.213	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
	Batch type Incinerator	kg-NOx/t	1.137	1.918	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
SO_2	Continuous Incinerator	kg-SO_2/t	0.555	0.539	0.361	0.361	0.361	0.361	0.361	0.361	0.361
	Semi-Continuous Incinerator	kg-SO_2/t	0.627	1.141	0.712	0.712	0.712	0.712	0.712	0.712	0.712
	Batch type Incinerator	kg-SO_2/t	1.073	1.625	1.714	1.714	1.714	1.714	1.714	1.714	1.714
	Gasification melting furnace	kg-SO_2/t	0.555	0.539	0.361	0.361	0.361	0.361	0.361	0.361	0.361

The data after 2000 were used for 2001 and subsequent years.

Source: *Research of Air Pollutant Emissions from Stationary Sources* (Ministry of the Environment)

➢ ***CO***

For incinerators, based on the emission factors for individual facilities summarized in the Reports on Greenhouse gas emissions estimation methodology (Japan Sociality Atmospheric Environment, 1996) as well as other reports, the emission factors were established for each incinerator class. It should be noted that while the Atmospheric Environment Society 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 weighting the average of incinerated volume for each furnace.

For gasification melting furnaces, the value for continuous stoker furnaces with a similar incineration method was used.

Table A 3-36 CO emission factors for municipal waste incineration by facility type

	Furnace Type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
CO	Continuous Incinerator	g-CO/t	557	557	555	554	554	554	554	553	553
	Semi-Continuous Incinerator	g-CO/t	548	548	567	591	613	605	611	609	609
	Batch type Incinerator	g-CO/t	8,237	8,237	8,298	8,341	8,343	8,351	8,270	8,272	8,272
	Gasification melting furnace	g-CO/t	567	567	567	567	567	567	567	567	567

Source: *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996), 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 per 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 3-37 NMVOC emission factors for municipal waste incineration by facility type

	Furnace Type	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
NMVOC	Continuous Incinerator	g-NMVOC/t	0.9	0.9	0.9	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	2.4	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	1.3	1.3	1.3
	Gasification melting furnace	g-NMVOC/t	-	-	0.6	0.8	0.8	0.8	0.8	0.8	0.8

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 volume for each facility type as calculated by multiplying the incineration volume of municipal waste by the incineration rate for each facility type. The incineration volume 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 the Ministry of the Environment. The incineration rate was calculated in the Waste Treatment in Japan published by the Ministry of the Environment.

For gasification melting furnaces, the activity data used was the volume incinerated in gasification melting furnaces, calculated from data in the Ministry of the Environment's "*Waste Treatment in Japan*."

A3.2.6.1.b. Industrial Wastes Incineration (6.C.–)

- ***Methodology for Estimating Emissions***

NO_X, CO, NMVOC, and SO_2 emissions from the specified sources were calculated by multiplying the incineration amount of industrial waste for each waste type by Japan's own emission factors. These emissions are categorized following the methods given in chapter 8 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_2***

An emission factor was established for each type of industrial solid waste using the emission volume and volume 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 3-38 NO_X and SO_2 emission factors for industrial waste by facility type

	Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
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
	"Industrial Waste 54"	kg-NOx/t	0.999	1.158	1.415	1.415	1.415	1.415	1.415	1.415	1.415
SO_2	"Fuel Wood 23"	kg-SO_2/t	1.528	1.274	2.118	2.118	2.118	2.118	2.118	2.118	2.118
	"Industrial Waste 54"	kg-SO_2/t	1.179	1.882	1.352	1.352	1.352	1.352	1.352	1.352	1.352

The data after 2000 were used for 2001 and subsequent years.

Source: Research of Air Pollutant Emissions from Stationary Sources (Ministry of the Environment)

➢ ***CO***

Based on the emission factors for individual facilities summarized in the *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996) 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 3-39 CO emission factors for industrial waste incinerators by operation type

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste Paper, Waste Wood	g-CO/t	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
Waste Plastics	g-CO/t	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
Waste textile	g-CO/t	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334
Animal and Plant residues	g-CO/t	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334	1,334

Source: *Reports on Greenhouse gas emissions estimation methodology* (Japan Sociality Atmospheric Environment, 1996) and others

➢ ***NMVOC***

NMVOC emission factors were established by multiplying the CH_4 emission factors for each furnace type per 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 3-40 NMVOC emission factors for industrial waste incineration by facility type

Item	Unit	1990	1995	2000	2005	2008	2009	2010	2011	2012
Waste Paper, Waste Wood	g-NMVOC/t	2.48	2.48	2.48	25.28	25.28	25.28	25.28	25.28	25.28
Waste Oil	g-NMVOC/t	0.54	0.54	0.54	0.45	0.45	0.45	0.45	0.45	0.45
Waste Plastics	g-NMVOC/t	3.40	3.40	3.40	0.90	0.90	0.90	0.90	0.90	0.90
Sludge	g-NMVOC/t	1.61	1.61	1.61	0.17	0.17	0.17	0.17	0.17	0.17
Waste textile	g-NMVOC/t	2.48	2.48	2.48	25.28	25.28	25.28	25.28	25.28	25.28
Animal and Plant residues	g-NMVOC/t	2.48	2.48	2.48	25.28	25.28	25.28	25.28	25.28	25.28

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 volume 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 the Ministry of the Environment.

A3.2.6.1.c. Incineration in Conjunction with Use of Waste as Fuel and Raw Material (1.A.-)

- ***Methodology for Estimating Emissions***

  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 8 (Waste).

- ***Emission Factors***

➢ ***CO***

The CO emission factors (fixed unit basis) for furnace types, which are used for counting emissions from 1A Stationary Sources, were determined by using the calorific values in *General Energy Statistics* to convert to weight-based emission factors. For the calorific values of waste tires from FY2005 and on, values from the Agency for Natural Resources and Energy's "The *Reexamination of Standard Calorific Values and Their Revised Values to Be Applied from FY2005 and on*" (2007) were used.

Table A 3-41 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 3-42 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***

  We used the same activity data that were used when estimating CH_4 emissions from the use of waste as fuel and raw material.

A3.2.7. Other sectors

A3.2.7.1. Smoking (7.–: CO)

- ***Methodology for Estimating Emissions***

  CO emissions were calculated by multiplying the volume of cigarette sales by Japan's own emission factor.

- ***Emission factor***

  The emission factor (0.055 [g-CO/cigarette]) was provided by Japan Tobacco Inc.

- ***Activity data***

  The volume 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. CO_2 Reference Approach and Comparison with Sectoral Approach, and Relevant Information on the National Energy Balance

This chapter explains a comparison between reference approach and sectoral approach in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (FCCC/SBSTA/2006/9, paragraph 31).

A4.1. Difference in Energy Consumption

As shown in Table A 4-1, fluctuations of difference[1] of energy consumption between the reference approach and the sectoral approach during 1990-2012 range between -3.11% (FY2002) and -0.29% (FY2008). It is relatively low compared to the inventories from other countries.

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 *1996 Revised IPCC Guidelines* and the *GPG (2000)*.

The difference between those two approaches for solid fuels in 2008 was a large value (5.91%), while the difference in 2009 was minus (-1.08%). It means that, in 2008, the coal on the consumer side (imported steam coal [$130[2]]) 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 drawdown 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 of provider side but of consumer side.

Table A 4-1 Comparison of energy consumption

[10^{15}J]

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Reference Approach									
Liquid fuels	9,689	10,191	9,503	8,913	7,850	7,174	7,241	7,640	7,758
Solid fuels	3,270	3,603	4,175	4,736	4,894	4,354	4,940	4,616	4,822
Gaseous fuels	2,097	2,534	3,130	3,388	4,013	3,975	4,227	4,921	5,092
Other fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total RA	**15,056**	**16,328**	**16,809**	**17,037**	**16,757**	**15,503**	**16,408**	**17,176**	**17,672**
Sectoral Approach									
Liquid fuels	9,550	10,051	9,450	8,903	7,726	7,103	7,188	7,666	7,784
Solid fuels	3,354	3,635	4,118	4,808	4,621	4,401	4,737	4,542	4,735
Gaseous fuels	2,106	2,548	3,137	3,368	4,021	4,011	4,238	4,926	5,114
Other fuels	259	294	348	436	438	420	425	424	419
Total	**15,268**	**16,529**	**17,052**	**17,515**	**16,806**	**15,936**	**16,587**	**17,559**	**18,052**
Difference (%)									
Liquid fuels	1.46%	1.39%	0.56%	0.11%	1.60%	1.01%	0.74%	-0.35%	-0.34%
Solid fuels	-2.50%	-0.88%	1.39%	-1.51%	5.91%	-1.08%	4.30%	1.63%	1.85%
Gaseous fuels	-0.44%	-0.55%	-0.20%	0.61%	-0.19%	-0.91%	-0.26%	-0.12%	-0.43%
Other fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	**-1.39%**	**-1.21%**	**-1.43%**	**-2.73%**	**-0.29%**	**-2.71%**	**-1.08%**	**-2.18%**	**-2.10%**

[1] Difference = [(Reference approach)-(Sectoral approach)]/(Sectoral approach)
[2] Code number of the *General Energy Statistics* (Energy Balance Table)

A4.2. Difference in CO_2 Emissions

As shown in Table A 4-2, fluctuations of a difference of CO_2 emissions between the reference approach and the sectoral approach during 1990-2012 range between -1.92% (FY2002) and 1.96% (FY2008).

Emissions from wastes used for energy and from the incineration of wastes with energy recovery are not reported in waste incineration (6.C.) but reported in fuel combustion (1.A.) in accordance with the *1996 Revised IPCC Guidelines* and the *GPG (2000)*.

The difference between both approaches for solid fuels in 2008 was a large value (5.26%), while the difference in 2009 was minus (-1.85%). It is because of the same reason as the energy consumption which is described in the previous page.

Table A 4-2 Comparison of CO_2 emissions

[Tg-CO_2]

	1990	1995	2000	2005	2008	2009	2010	2011	2012
Reference Approach									
Liquid fuels	659.1	692.4	647.0	606.4	534.5	488.8	493.5	520.7	529.0
Solid fuels	294.6	324.2	377.6	428.7	442.6	394.1	447.5	417.8	436.4
Gaseous fuels	103.7	125.3	154.8	167.6	198.5	196.6	209.0	243.3	251.7
Other fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total RA	**1,057**	**1,142**	**1,179**	**1,203**	**1,176**	**1,080**	**1,150**	**1,182**	**1,217**
Sectoral Approach									
Liquid fuels	646.2	677.3	635.1	597.8	518.4	475.0	481.3	514.5	523.0
Solid fuels	308.6	331.7	376.5	437.9	420.5	401.6	431.5	413.6	431.1
Gaseous fuels	104.3	126.2	155.3	166.8	199.5	198.7	210.7	245.0	253.5
Other fuels	9.1	10.5	13.1	15.1	14.6	13.6	13.5	13.8	14.0
Total	**1,068**	**1,146**	**1,180**	**1,218**	**1,153**	**1,089**	**1,137**	**1,187**	**1,222**
Difference (%)									
Liquid fuels	1.99%	2.23%	1.87%	1.43%	3.11%	2.91%	2.52%	1.19%	1.14%
Solid fuels	-4.54%	-2.26%	0.29%	-2.11%	5.26%	-1.85%	3.72%	1.01%	1.23%
Gaseous fuels	-0.57%	-0.71%	-0.32%	0.44%	-0.53%	-1.08%	-0.81%	-0.72%	-0.69%
Other fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	**-1.01%**	**-0.33%**	**-0.06%**	**-1.24%**	**1.96%**	**-0.85%**	**1.14%**	**-0.44%**	**-0.36%**

A4.3. 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.

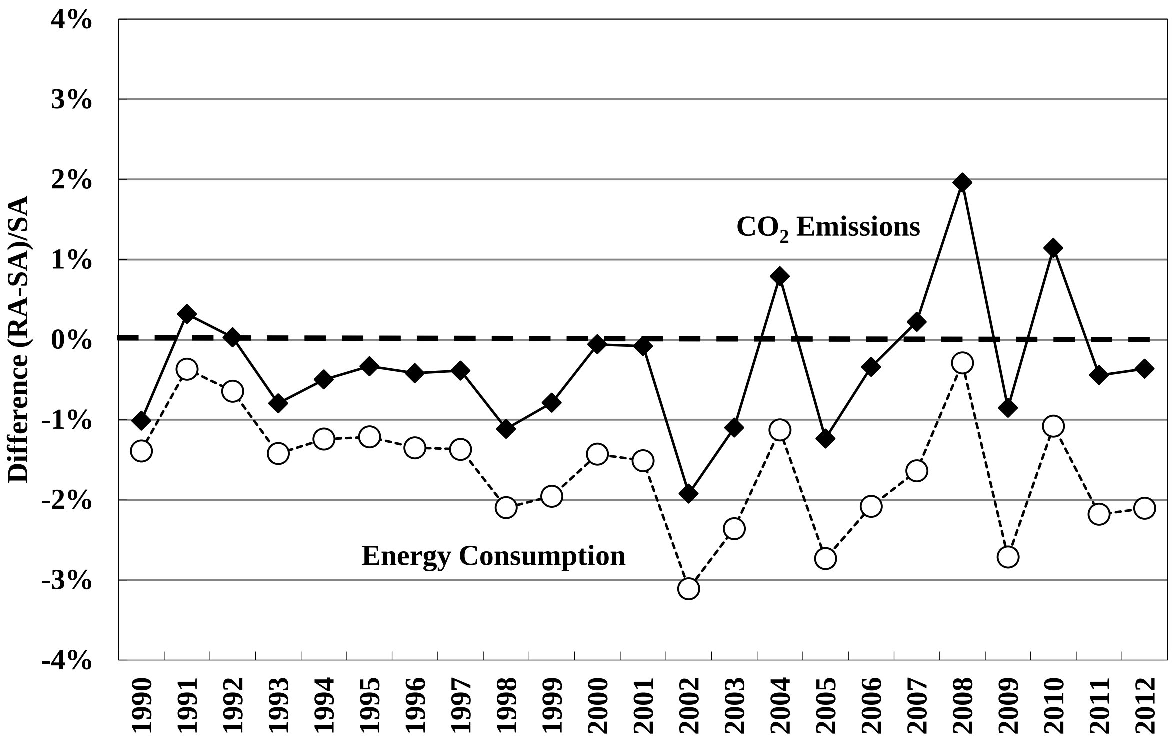

Figure A 4-1 Trends in difference of energy consumption and CO_2 emissions

A4.4. 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 'other conversions & blending' [#2700], 'other input/output' [#3000], 'stock change' [#3500], 'statistical discrepancy' [#4000] ,and "energy loss" and "carbon imbalance" of 'oil products' [#2600] of the Energy Balance Table (*General Energy Statistics*).

The default values given in the *Revised 1996 IPCC Guidelines* were used for the fractions of carbon stored for feedstock and non-energy in reference approach.

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 included in reference approach.

- **Other Input/Output [#3000]**

In oil refining and other parts of the energy conversion sector, 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 conversion sector are determined, the other input/output sector accounts for the amount. However, this input/output are not reflected under reference approach emission calculation.

- **Stock Change [#3500]**

The increase or decrease of stock were not reflected under reference approach emission calculation.

CO_2 emissions from wastes used for energy and from the incineration of wastes with energy recovery originate 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.

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

- **Statistical Discrepancy [#4000]**

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 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

- **Other Conversions & Blending [#2700]**

This sector represents energy conversion that does not belong to any of the sectors from #2100 commercial power generation to #2600 oil products, 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.

- **Oil Products [#2600]**

Energy loss and carbon imbalance during the process of oil production produce the difference between input and output of energy or carbon.

Table A 4-3 Comparison of CO_2 emissions (detail)

[Gg-CO_2]

	1990	1995	2000	2005	2008	2009	2010	2011	2012
RA	**1,057,427**	**1,141,966**	**1,179,346**	**1,202,642**	**1,175,623**	**1,079,513**	**1,149,976**	**1,181,669**	**1,217,111**
Liquid fuels	659,104	692,444	646,974	606,374	534,521	488,827	493,451	520,657	528,983
Solid fuels	294,611	324,221	377,604	428,702	442,626	394,132	447,538	417,753	436,417
Gaseous fuels	103,711	125,302	154,767	167,566	198,476	196,554	208,987	243,259	251,711
Other fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA
SA	**1,068,260**	**1,145,769**	**1,180,044**	**1,217,697**	**1,153,045**	**1,088,802**	**1,136,981**	**1,186,937**	**1,221,568**
Liquid fuels	646,223	677,347	635,112	597,801	518,386	474,991	481,302	514,536	523,003
Solid fuels	308,620	331,720	376,520	437,937	420,521	401,558	431,474	413,571	431,097
Gaseous fuels	104,301	126,200	155,269	166,836	199,534	198,692	210,694	245,018	253,456
Other fuels	9,116	10,503	13,142	15,124	14,603	13,561	13,511	13,811	14,012
RA-SA	**-10,833**	**-3,803**	**-698**	**-15,055**	**22,578**	**-9,289**	**12,994**	**-5,268**	**-4,457**
Liquid fuels	12,882	15,097	11,862	8,573	16,135	13,835	12,149	6,121	5,980
Solid fuels	-14,009	-7,499	1,084	-9,235	22,105	-7,425	16,064	4,182	5,320
Gaseous fuels	-589	-898	-502	730	-1,058	-2,138	-1,707	-1,760	-1,744
Other fuels	-9,116	-10,503	-13,142	-15,124	-14,603	-13,561	-13,511	-13,811	-14,012
Statistical Discrepancy	**-10,465**	**3,381**	**-1,258**	**-19,607**	**12,460**	**4,855**	**18,516**	**7,616**	**9,542**
Liquid fuels	-3,708	3,839	-5,664	-15,724	1,239	814	1,120	2,403	879
Solid fuels	-6,796	-693	3,915	-4,361	11,586	4,665	18,226	6,751	10,130
Gaseous fuels	39	236	491	478	-366	-624	-829	-1,537	-1,467
Other Conversions & Blending	**-2,828**	**-3,076**	**-1,189**	**-1,110**	**-1,134**	**-979**	**-1,406**	**-1,666**	**-2,042**
Liquid fuels	803	1,058	1,119	1,193	1,082	1,055	984	998	799
Solid fuels	-2,807	-3,078	-1,121	-1,059	-1,044	-901	-1,284	-1,589	-1,801
Gaseous fuels	-825	-1,056	-1,186	-1,244	-1,172	-1,134	-1,106	-1,076	-1,041
Stock Change	**1,452**	**1,878**	**2,225**	**556**	**15,694**	**-9,876**	**2,733**	**1,249**	**2,843**
Liquid fuels	788	1,311	-976	270	1,740	-689	441	-995	2,604
Solid fuels	681	757	2,934	-1,097	13,635	-8,585	2,370	1,707	-192
Gaseous fuels	-18	-190	268	1,383	318	-602	-78	537	431
Other Input/Output	**-895**	**-642**	**2,106**	**2,577**	**1,374**	**1,429**	**2,509**	**-4,212**	**-5,795**
Liquid fuels	-895	-642	2,106	2,577	1,374	1,429	2,509	-4,212	-5,795
Solid fuels	0	0	0	0	0	0	0	0	0
Gaseous fuels	0	0	0	0	0	0	0	0	0
Oil Products	**1,257**	**1,057**	**6,121**	**10,182**	**3,016**	**4,250**	**-1,569**	**-428**	**-3,496**
Liquid fuels	1,518	1,351	6,476	10,600	3,387	4,494	-1,330	-202	-3,283
Solid fuels	0	0	0	0	0	0	0	0	0
Gaseous fuels	-261	-294	-355	-418	-371	-244	-239	-226	-213
Total	**-11,478**	**2,598**	**8,004**	**-7,401**	**31,410**	**-321**	**20,783**	**2,559**	**1,052**
Liquid fuels	-1,493	6,917	3,060	-1,083	8,824	7,103	3,723	-2,008	-4,794
Solid fuels	-8,921	-3,015	5,727	-6,517	24,177	-4,820	19,312	6,868	8,137
Gaseous fuels	-1,064	-1,304	-783	199	-1,591	-2,604	-2,253	-2,302	-2,291
(RA-SA)-(Total)	**645**	**-6,401**	**-8,703**	**-7,654**	**-8,832**	**-8,969**	**-7,788**	**-7,827**	**-5,509**
Liquid fuels	14,375	8,180	8,802	9,656	7,311	6,732	8,425	8,129	10,774
Solid fuels	-5,088	-4,484	-4,643	-2,718	-2,072	-2,606	-3,248	-2,687	-2,817
Gaseous fuels	474	406	280	531	533	466	546	542	546
Other fuels	-9,116	-10,503	-13,142	-15,124	-14,603	-13,561	-13,511	-13,811	-14,012

Annex 5. Assessment of Completeness and (Potential) Sources and Sinks of Greenhouse Gas Emissions and Removals Excluded

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[1] 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, both of which are based on the UNFCCC reporting Guidelines (FCCC/CP/1999/7, FCCC/CP/2002/8, FCCC/SBSTA/2004/8 or FCCC/SBSTA/2006/9) and the results of Committee for Greenhouse Gases Emissions Estimation Methods in 2002.

This chapter also reports source categories which have not been estimated because i) applicability of IPCC default values is not assured, ii) default methodologies and default values are not provided, iii) activity data is not available, iv) actual condition of GHG emissions or removals is not understood clearly.

A5.2. Definition of Notation Keys

When reviewing the appropriateness of applying notation keys shown in the UNFCCC reporting guideline, it is necessary to establish a common concept for an application of these keys for each sector, but unclear points described in Table A5-1 are found as below regarding the use of the notation key.

- The explanation of "NO" in the UNFCCC reporting guidelines can be taken that "NO" may be applied to both situations when there are no emissions or removals because the activities do not exist in Japan, and when emissions or removals do not occur in principle although the activities do exist.

- The first sentence of the "NA" explanation in the UNFCCC reporting guidelines seems to imply that "NA" may be applied to both situations as for "NO". However, because the second sentence states that "If categories... are shaded, they do not need to be filled in", it also seems to mean that "NA" is applied only when the activities exist but there are no emissions or removals in principle.

In the Committee for Greenhouse Gases Emissions Estimation Methods in 2002, the meanings of the notation keys are defined based on the following policy (as shown in Table A5-2).

- It was decided that "NA" is applied when the activity does exist in Japan, but in principle there are no GHG emissions or removals, while "NO" will apply when the activity itself does not exist and there are no emissions or removals.

[1] These were called "standard indicators" in FCCC/CP/1999/7, but were changed to "notation keys" in FCCC/CP/2002/8.

If the UNFCCC reporting guidelines are revised in future, the review of the definitions of notation keys and the way to fill them in CRF will be conducted.

Table A 5-1 Notation keys indicated in UNFCCC reporting guidelines

Notation Key	Explanation
NO (Not Occurring)	"NO" (not occurring) for emissions by sources and removals by sinks of greenhouse gases that do not occur for a particular gas or source/sink category within a country;
NE (Not Estimated)	"NE" (not estimated) for existing emissions by sources and removals by sinks of greenhouse gases which have not been estimated. Where "NE" is used in an inventory for emissions or removals of CO_2, CH_4, N_2O, HFCs, PFCs or SF_6, the Party should indicate why emissions could not be estimated, using the completeness table of the common reporting format;
NA (Not Applicable)	"NA" (not applicable) for activities in a given source/sink category that do not result in emissions or removals of a specific gas. If categories in the common reporting format 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 greenhouse gases estimated but included elsewhere in the inventory instead of the expected source/sink category. Where "IE" is used in an inventory, the Party should indicate, using the completeness table of the common reporting format, where in the inventory the emissions or removals from the displaced source/sink category have been included and the Party should give the reasons for this inclusion deviating from the expected category;
C (Confidential)	"C" (confidential) for emissions by sources and removals by sinks of greenhouse gases which could lead to the disclosure of confidential information, given the provisions of paragraph 27 above; (para 27: Emissions and removals should be reported on 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 inventories (FCCC/SBSTA/2004/8)

* The notation key "0" was deleted at COP8 from the revised UNFCCC reporting guidelines (FCCC/CP/2002/8).

Table A 5-2 Definition of Notation Keys

Notation Key	Definition
NO (Not Occurring)	Used when there are no activities that are linked to emissions or removals for a certain source.
NE (Not Estimated)	Used when the emissions or removals of a certain source cannot be estimated.
NA (Not Applicable)	Used when an activity associated with a certain source does exist, but in principle it accompanies no occurrence of specific GHG emissions or removals. "NA" is not applied when there are no GHG emissions or removals because the GHGs in raw materials have been removed.
IE (Included Elsewhere)	IE is used when an emissions or removals are already included in other sources. For assuring the completeness of CRF, the sources in which the emissions or removals are included and the reasons for including it elsewhere are to be recorded in the table.
C (Confidential)	Used for confidential information relating to business or the military. However, in consideration of transparency in calculation of emissions or removals, information will be reported to the extent that it does not hinder business or other operations (for example, reporting the aggregated total of several substances).

A5.3. Decision Tree for Application of Notation Keys

Decision tree for the application of notation keys, based on UNFCCC reporting Guidelines (FCCC/CP/1999/7 FCCC/CP/2002/8, FCCC/SBSTA/2004/8 or FCCC/SBSTA/2006/9) and the results of Committee for Greenhouse Gases Emissions Estimation Methods in 2002, is shown in Figure A5-1.

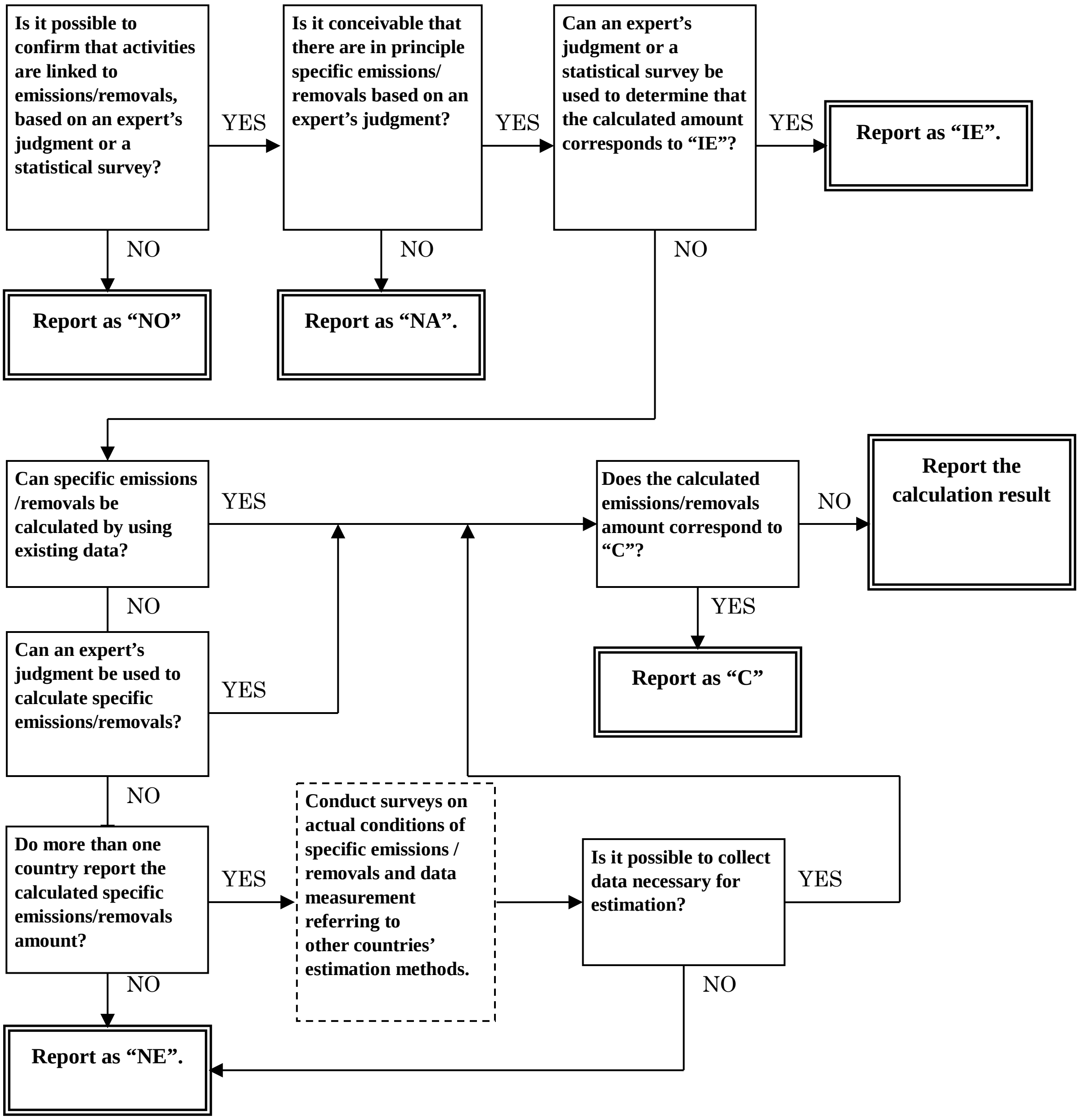

Figure A 5-1 Decision tree for application of notation keys

A5.4. Source categories not estimated in Japan's inventory

Source categories dissolved not estimate status in this year and categories still not estimated in Japan's inventory are listed below.

Table A 5-3 Dissolution of "NE" categories for FY2012

Code	Sector	Source category				Gas
1	Industrial Processes	Metal Production				PFCs, SF_6
2	Industrial Processes	Production of Halocarbons and SF_6				HFCs, PFCs, SF_6
3	Industrial Processes	Consumption of Halocarbons and SF_6				HFCs, PFCs, SF_6
4	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Wild land	Living Biomass	Carbon Stock Change
5	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Wild land	Dead Organic Matter	Carbon Stock Change
6	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Wild land	Soil	Carbon Stock Change

Table A 5-4 "NE" categories for FY2012

Code	Sector	Source category				GHG
1	Energy	Fugitive Emissions from Fuels	Solid Fuels	Coal Mining		CO_2
2	Energy	Fugitive Emissions from Fuels	Solid Fuels	Coal Mining		N_2O
3	Energy	Fugitive Emissions from Fuels	Solid Fuels	Solid Fuel Transformation		CO_2
4	Energy	Fugitive Emissions from Fuels	Solid Fuels	Solid Fuel Transformation		CH_4
5	Energy	Fugitive Emissions from Fuels	Solid Fuels	Solid Fuel Transformation		N_2O
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	Industrial Processes	Mineral Products	Asphalt roofing			CO_2
10	Industrial Processes	Mineral Products	Road Paving with Asphalt			CO_2
11	Industrial Processes	Chemical Industry	Ammonia Production			CH_4
12	Industrial Processes	Metal Production	Aluminium Production			CH_4
13	Solvent and Other Product Use	Degreasing and Dry-Cleaning				CO_2
14	Solvent and Other Product Use	Chemical Product, Manufacture and Processing				CO_2
15	Solvent and Other Product Use	Other	Other Use of N_2O			N_2O
16	Agriculture	Enteric Fermentation	Poultry			CH_4
17	Agriculture	Field Burning of Agricultural Residues	Other			CH_4
18	Agriculture	Field Burning of Agricultural Residues	Other			N_2O
19	Land - use Change and Forestry	Cropland	Cropland remaining Cropland	Biomass Burning	Controlled Burning	CO_2
20	Land - use Change and Forestry	Cropland	Cropland remaining Cropland	Biomass Burning	Controlled Burning	CH_4
21	Land - use Change and Forestry	Cropland	Cropland remaining Cropland	Biomass Burning	Controlled Burning	N_2O
22	Land - use Change and Forestry	Cropland	Land Converted to Cropland	Other Land converted to Cropland	Dead Organic Matter	Carbon Stock Change
23	Land - use Change and Forestry	Cropland	Land Converted to Cropland	Other Land converted to Cropland	Soil (mineral soil)	Carbon Stock Change
24	Land - use Change and Forestry	Cropland	Land Converted to Cropland	N_2O emissions from disturbance	Soil	N_2O
25	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Grazed meadow	Soil	Carbon Stock Change
26	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	CO_2
27	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	CH_4
28	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Wildfires	N_2O
29	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	CO_2
30	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	CH_4
31	Land - use Change and Forestry	Grassland	Grassland remaining Grassland	Biomass Burning	Controlled Burning	N_2O
32	Land - use Change and Forestry	Grassland	Land Converted to Grassland	Other Land converted to Grassland	Dead Organic Matter	Carbon Stock Change
33	Land - use Change and Forestry	Grassland	Land Converted to Grassland	Other Land converted to Grassland	Soil (mineral soil)	Carbon Stock Change
34	Land - use Change and Forestry	Grassland	Land Converted to Grassland	Biomass Burning	Wildfires	CO_2
35	Land - use Change and Forestry	Grassland	Land Converted to Grassland	Biomass Burning	Wildfires	CH_4
36	Land - use Change and Forestry	Grassland	Land Converted to Grassland	Biomass Burning	Wildfires	N_2O
37	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Flooded land	Living Biomass	Carbon Stock Change
38	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Flooded land	Dead Organic Matter	Carbon Stock Change
39	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Flooded land	Soil	Carbon Stock Change
40	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Wildfires	CO_2
41	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Wildfires	CH_4
42	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Wildfires	N_2O
43	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Controlled Burning	CO_2
44	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Controlled Burning	CH_4
45	Land - use Change and Forestry	Wetlands	Wetlands remaining Wetlands	Biomass Burning	Controlled Burning	N_2O
46	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Cropland converted to Wetlands	Soil	Carbon Stock Change
47	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Grassland converted to Wetlands	Soil	Carbon Stock Change
48	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Settlements converted to Wetlands	Soil	Carbon Stock Change
49	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Other Land converted to Wetlands	Dead Organic Matter	Carbon Stock Change
50	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Other Land converted to Wetlands	Soil	Carbon Stock Change
51	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Biomass Burning	Wildfires	CO_2
52	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Biomass Burning	Wildfires	CH_4
52	Land - use Change and Forestry	Wetlands	Land converted to Wetlands	Biomass Burning	Wildfires	N_2O
53	Land - use Change and Forestry	Settlements	Settlements remaining Settlements			CH_4
54	Land - use Change and Forestry	Settlements	Settlements remaining Settlements			N_2O
55	Land - use Change and Forestry	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Living Biomass	Carbon Stock Change
56	Land - use Change and Forestry	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Dead Organic Matter	Carbon Stock Change
57	Land - use Change and Forestry	Settlements	Settlements remaining Settlements	Other than Urban Green Areas	Soil	Carbon Stock Change
58	Land - use Change and Forestry	Settlements	Settlements remaining Settlements	Urban Green Areas not subject to RV	Dead Organic Matter	Carbon Stock Change
59	Land - use Change and Forestry	Settlements	Settlements remaining Settlements	Urban Green Areas not subject to RV	Soil	Carbon Stock Change
60	Land - use Change and Forestry	Other land	Land Converted to Other land	Cropland Converted to Other land	Soil	Carbon Stock Change
61	Land - use Change and Forestry	Other land	Land Converted to Other land	Grassland Converted to Other land	Soil	Carbon Stock Change
62	Land - use Change and Forestry	Harvested Wood Product				CO_2
63	Land - use Change and Forestry	Harvested Wood Product				CH_4
64	Land - use Change and Forestry	Harvested Wood Product				N_2O

Annex 6. Additional Information to be Considered as Part of the NIR Submission or Other Useful Reference Information

A6.1. Details on Inventory Compilation System and QA/QC Plan

The main parts of the QA/QC Plan for Japan's greenhouse gas inventory are excerpted.

A6.1.1. Introduction to 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 National Inventory Report 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.

A6.1.2. QA/QC plan's scope

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 Article 7.1 of the Protocol.

A6.1.3. 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 Kyoto Protocol Article 5.1.
- It is responsible for editing and submitting the inventory.

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.

- Preparation of activity data, emission factor data, and other data needed for inventory compilation, and submission of the data by the submission deadline.
- Quality control (QC) of the data provided to the Ministry of the Environment and the GIO.
- Confirmation and verification of the inventory (CRF, NIR, spreadsheets, and other information) prepared by the Ministry of the Environment and 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.

- Preparation of activity data, emission factor data, and other data needed for inventory compilation, and submission of the data by the submission deadline.
- (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. Improvement suggestions are considered once more by the Committee before approval.

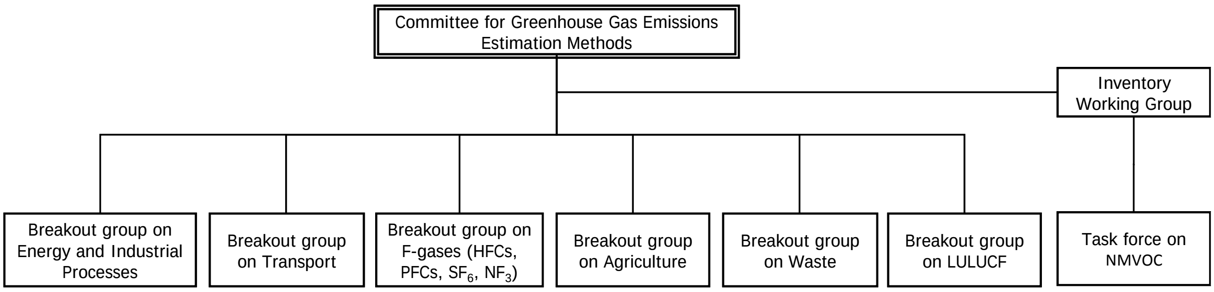

Figure A 6-1 Structure of the Committee for the Greenhouse Gas Emissions Estimation Methods

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, spreadsheets, 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.

A6.1.4. 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. Since FY2009, the Network of Official Greenhouse Gas Inventory System for Total Management (NOGISTOM) has been used for data collection. This system manages all the information related to provision of data. The main relevant ministries and agencies and relevant organizations that provide data are as shown in Table A 6-1.

Table A 6-1 List of the main relevant ministries and agencies and the relevant organizations (data providers)

Ministries/Agencies/Organizations		Major data or statistics
Relevant Ministries/ Agencies	Ministry of the Environment	Research of Air Pollutant Emissions from Stationary Sources / volume of waste in landfill / volume of incinerated waste / number of people per *johkasou* facility / volume of human waste treated at human waste treatment facilities
	Ministry of Economy, Trade and Industry	General Energy Statistics / Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke / Yearbook of Iron and Steel, Non-ferrous Metals, and Fabricated Metals Statistics / Yearbook of Chemical Industry Statistics / Yearbook of Ceramics and Building Materials Statistics / Census of Manufactures / General outlook on electric power supply and demand
	Ministry of Land, Infrastructure, Transport and Tourism	Annual of Land Transport Statistics / Survey on Transport Energy / Statistical Yearbook of Motor Vehicle Transport / Survey on Current State of Land Use,Survey on Current State of Urban Park Development / Sewage Statistics
	Ministry of Agriculture, Forestry and Fisheries	Crop Statistics / Livestock Statistics / Vegetable Production and Shipment Statistics / World Census of Agriculture and Forestry / Statistics of Arable and Planted Land Area / Handbook of Forest and Forestry Statistics / Table of Food Supply and Demand
	Ministry of Health, Labour and Welfare	Statistics of Production by Pharmaceutical Industry
Relevant Organizations	Federation of Electric Power Companies	Amount of Fuel Used by Pressurized Fluidized Bed Boilers
	Japan Coal Energy Center	Coal Production
	Japan Cement Association	Amount of clinker production / Amount of waste input to in raw material processing / Amount of RPF incineration
	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

A6.1.5. 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 *1996*

Revised IPCC Guidelines, *GPG (2000)*, *GPG-LULUCF*, and the *2006 IPCC Guidelines*.

A6.1.6. Improvement process of estimations for emissions and removals

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 A 6-2 below is a diagram of the inventory improvement process.

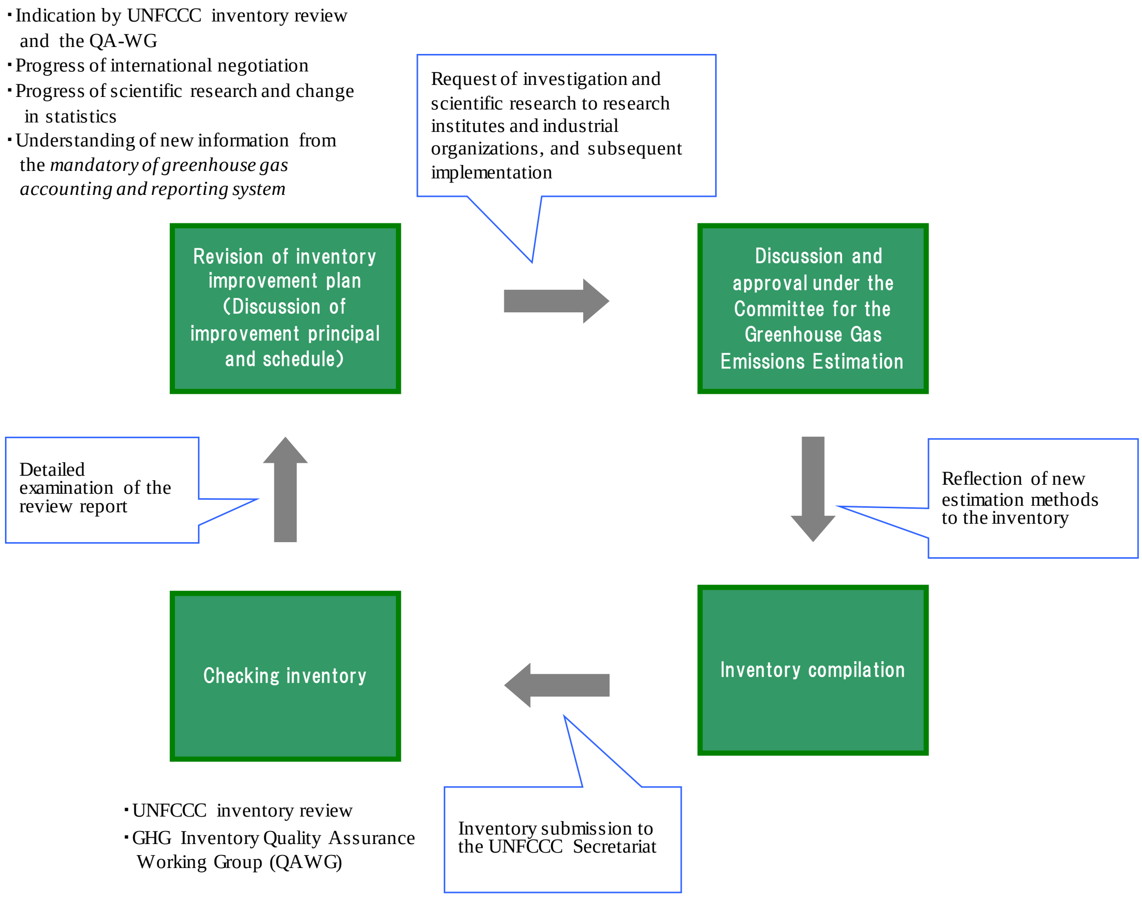

Figure A 6-2 Diagram of the inventory improvement process

A6.1.7. QA/QC activity

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 *GPG (2000)* and *GPG-LULUCF*. 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 verify and assess data quality from the perspectives of scientific knowledge and data availability with respect to current calculation methods. Table A 6-2 sketches Japan's QA/QC activities.

Table A 6-2 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 (Tier1 QC) ・Archiving QA/QC activity records and relevant data and documents ・Developing inventory improvement plan ・Revising QA/QC plan
	Relevant Ministry and Agencies (including the Ministry of the Environment)	・Checking data necessary for inventory preparation ・Checking JNGI files and inventory prepared by GIO (Tier2 QC)
	Committee for the Greenhouse Gas Emissions Estimation Methods	・Discussing and assessing estimation methods, emission factors, and activity data (Tier2 QC)
	Private Consultant Companies	・Checking JNGI files and inventory prepared by GIO (Tier2 QC)
QA (Quality Assurance)	Inventory Quality Assurance Working Group (QAWG)	・Conducting expert peer review of inventory (QA)

A6.1.7.1. QC activity

A6.1.7.1.a. General QC procedures (Tier 1)

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 data are corrected after the coordination with the relevant ministries and agencies

A6.1.7.1.b. QC procedure for each category (Tier 2)

As part of the QC activities in Japan, private consultant companies perform external QC on the estimation files prepared by the GIO, and on the CRF and NIR drafts. In addition to confirming the data entered into estimation files for each emission source category and the equations for calculating emissions, private consultant companies use estimation files like those of the GIO to calculate total greenhouse gas emissions, and carry out mutual verification of emission estimation results. They also send to the relevant ministries and agencies the sets of files for estimation files, CRF, NIR, and the drafts of published documents for domestic release showing estimated values for emissions and removals. And they confirm and verify the content of categories relevant to each ministry or agency (coordination with the relevant ministries and agencies).

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 Tier 2 QC activities.

A6.1.7.2. 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 following QA is conducted to assure inventory quality.

- GHG Inventory Quality Assurance Working Group (Expert Peer Review)

A6.1.7.2.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.

- 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） QAWG in FY2012

The QAWG was newly established in FY2009 as a result of discussions within the Committee held in FY2008 in order to enhance Japan’s QA/QC 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. The secretariat for the QAWG was established within the GIO. The secretariat and the Ministry of the Environment determined the sectors and categories to be reviewed by the QAWG. The experts for the QAWG were selected by taking the following requirements into account.

<Requirements for QAWG review expert>

a. No direct involvement in the inventory preparation process for estimating emissions/ removals from the sectors/categories to be reviewed (i.e., no involvement in the Committee, the data creation and the data provision for those sectors/categories)
b. No specific interests related to the inventory and the capability to judge objectively without being affected by any specific organizations and/or stakeholders.
c. Sufficient skills, knowledge and experiences to assure the quality of the inventory

QA/QC activities as cross-cutting issues were reviewed by two experts in FY2013, and the schedule was as follows.

Table A 6-3 Schedule for the QAWG in FY2013

Schedule	Matter
Until August 2013	Selecting experts by the Ministry of the Environment of Japan and the secretariat
August	Visiting and providing an overview of QAWG activities to the experts
September to November	Review by the experts including one-day visit to GIO
4 December	Holding QAWG meeting
January, 2014	Reporting a summary of review results and QAWG activities to the Committee
March	Updating a summary of QAWG activities in NIR

Results of review conducted by QAWG in 2013 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 will be addressed and reflected in the revised QA/QC and inventory process in its next annual submissions. 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.

A6.1.8. 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[1], Kyoto Protocol Article 8, Decision 22/CMP.1, and other requirements. Specifically, rigorous checks are performed in accordance with Japan's prescribed estimation method guidelines[2] from perspectives including: Are emissions and removals accurately and completely estimated and reported? Are transparent explanations provided for estimation methods? Are QA/QC activities and uncertainty assessments performed appropriately?

Because the inventory review has great significance for attaining Japan's emission reduction targets under the Kyoto Protocol, it is necessary to address this matter after having made careful preparations. The system shown in Figure A 6-3 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. Communication with the UNFCCC Secretariat is performed by the Ministry of Foreign Affairs. The relevant ministries and agencies, relevant organizations, and private consultant companies[3] that are involved in inventory compilation cooperate with review response through activities including providing relevant information, support for source material preparation, and QC implementation.

[1] FCCC/CP/2002/8
[2] *1996 Revised IPCC Guidelines, Good Practice Guidance (2000)*、*GPG-LULUCF*
[3] Private consultant companies cooperate in correspondence of the reviews based on the operating agreement with the Ministry of the Environment.

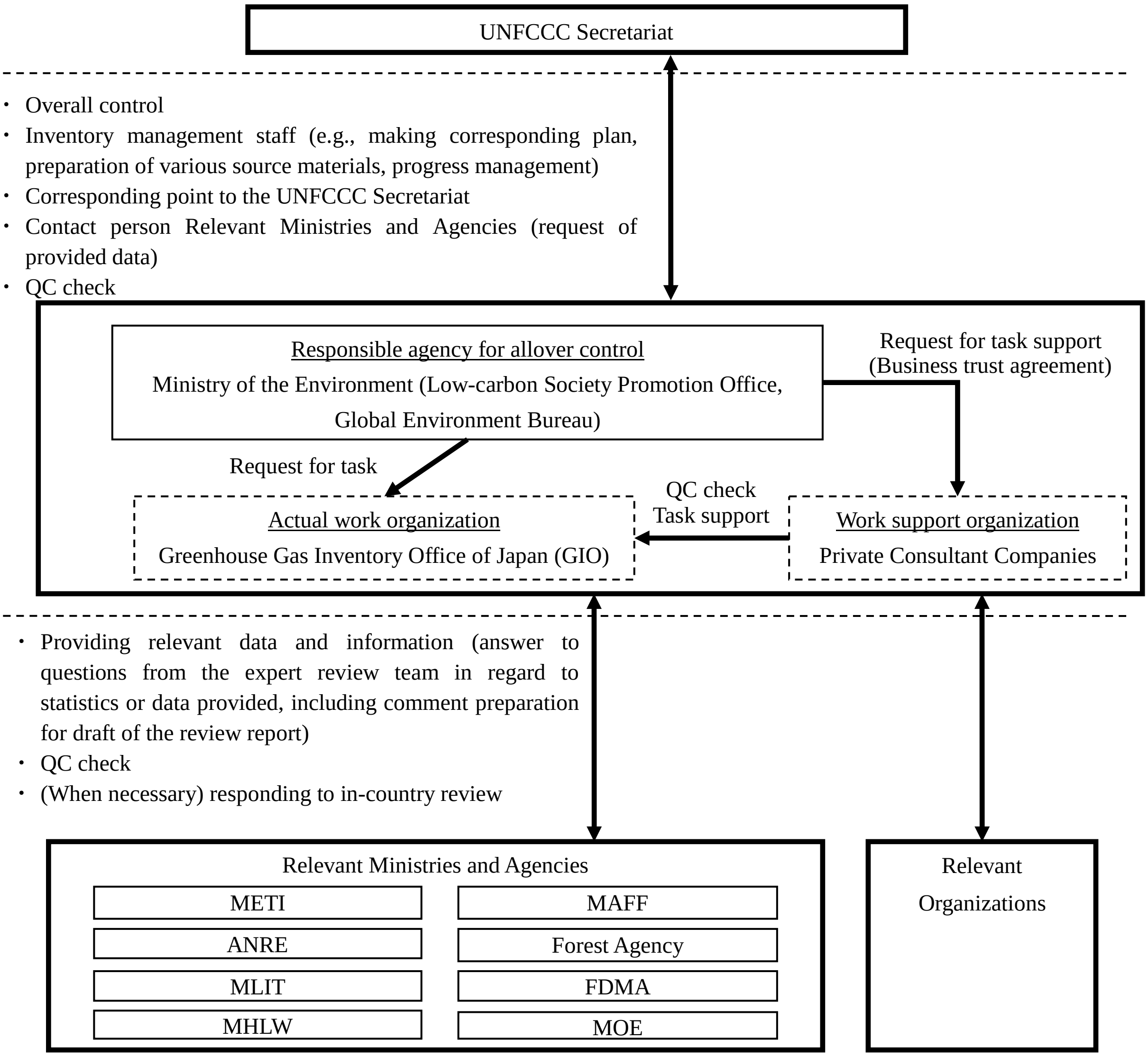

Figure A 6-3　Basic structure of Japan's national system corresponding to inventory review

A6.1.9. 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).

A6.1.9.1. 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 inventories submitted every year to the UNFCCC Secretariat, and the related files
- 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)
- Record of QA/QC activities conducted
- Comments by experts on the inventory
- In relation to UNFCCC inventory reviews, review reports and records of questions and answers with expert review teams
- Internal documents on inventory compilation, including the QA/QC Plan

A6.1.9.2. Archiving of information

1） Archiving electronic information

ⅰ） Inventory-related electronic information

- Each year's emissions/removals estimation 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. Furthermore, since data collection from relevant ministries and agencies and the relevant organizations is done via the NOGISTOM, the received data are also stored within this database.
- 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.

A6.1.9.3. 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.

Annex 7. Methodology and Results of Uncertainty Assessment

A7.1. Methodology of Uncertainty Assessment

A7.1.1. Background and Purpose

Under the United Nations Framework Convention on Climate Change (UNFCCC), Annex I Parties are required to submit their inventories on greenhouse gases emissions and removals (hereafter, ‘inventory’) to the UNFCCC secretariat. *Good Practice Guidance (2000),* adopted in May 2000, further requires parties to quantitatively assess and report the uncertainty of their inventories. It should be noted that uncertainty assessment is intended to contribute to continuous improvement in the accuracy of inventories and that a high or low uncertainty assessed will not affect the justice of an inventory nor result in the comparison of accuracy among parties’ inventories.

Japan considered uncertainty of its inventory in the Committee for the Greenhouse Gases Emissions Estimation Methods in FY2001 and again in FY2006. Japan has annually conducted uncertainty assessment based on the Committee’s results since then.

This chapter will be used as a guideline for conducting the uncertainty assessment of Japan’s inventories. It may be subjected to be adjusted as appropriate.

A7.1.2. Overview of Uncertainty Assessment Indicated in the Good Practice Guidance

A7.1.2.1. About Uncertainty Assessment

A7.1.2.1.a. What is uncertainty?

- The term “uncertainty” refers to the degree of discrepancy in various data in comparison with a true value, stemming from number of characteristics with lack of sureness including representational reliability of measurements, and it is a concept that is much broader than that of accuracy.
- The uncertainty of emissions from a particular source is obtained by calculating and applying the uncertainty associated with the source’s emission factor, and the uncertainty of activity data.
- The *Good Practice Guidance* requires uncertainty of emissions from a source to be calculated using the method given below.

$$U = \sqrt{U_{EF}^{\ 2} + U_{A}^{\ 2}}$$

U : Uncertainty of the emissions of the source [%]
U_{EF} : Uncertainty of the emission factor [%]
U_A : Uncertainty of the activity data [%]

A7.1.2.1.b. Methodology of identifying the uncertainties of emission factors and activity data of each source

- The standard deviations of the observed values of an emission factor are used to set the probability density function, and uncertainty is assessed by seeking a 95 percent confidence interval.

$$\text{Uncertainty of EF or A} = \frac{\text{95\% confidence interval / 2 } (n)}{|\text{ Adopted value of EF or A } (m)\ |}$$

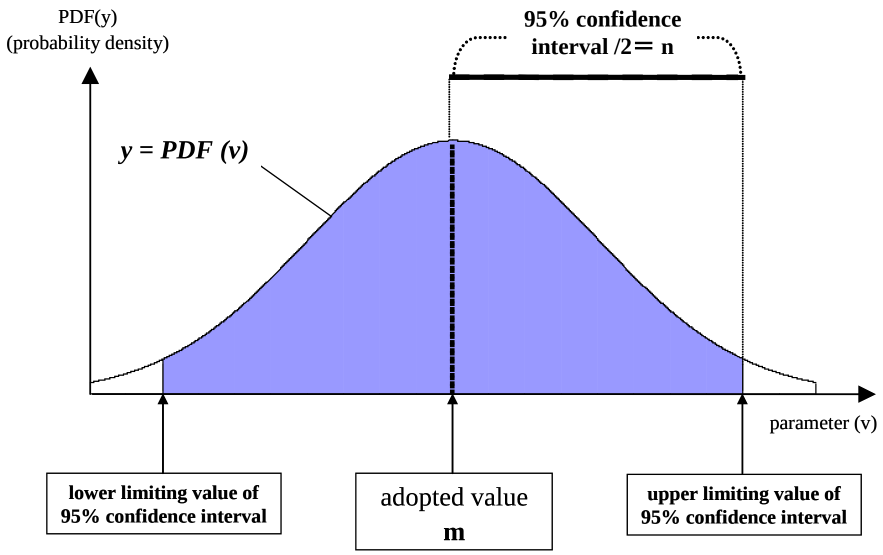

Figure A7-1 Probability density function (PDF) and confidence interval

A7.1.2.1.c. Method of determining the uncertainty of total national emissions

- By combining the uncertainties of emissions from all sources, it is possible to assess the uncertainty of Japan's total inventory.
- When there is no correlation between multiple uncertainties, and they are normally distributed, the *Good Practice Guidance* suggests two rules of expedience that relate to combining method (addition and multiplication) of uncertainties. This report adopts Rule A, given in Table 6.1 of the *Good Practice Guidance*, for the calculations.

$$U_{Total} = \frac{\sqrt{(U_1 \times E_1)^2 + (U_2 \times E_2)^2 + \cdots + (U_n \times E_n)^2}}{E_1 + E_2 + \cdots + E_n}$$

U_{Total} : Uncertainties of National Total Emissions [%]
U_i : Uncertainties of the Emissions from Source " i " [%]
E_i : the Emissions from Source " i " [Gg]

A7.1.2.2. Targets of the Uncertainty Assessment

The *Good Practice Guidance* suggests that all uncertainties be taken into account when estimating emissions. It indicates that the following may be the reasons of uncertainty in emission factors or activity data.

Examples of common reasons of uncertainty in emission factors
➢ Uncertainties associated with a continuous monitoring of emissions - Refers to uncertainties arising from differences in conditions at the time of measurement, such as measurements that are taken annually.
➢ Uncertainties associated with an establishment of emission factors - Startup and shutdown in operation of machinery, etc., can give different emission rates relative to activity data. In these cases, the data should be partitioned, with separate emission factors and probability density functions derived for steady-state, startup and shutdown conditions.

- Emission factors may depend on load of operation. In these cases, the estimation of total emissions and the uncertainty analysis may need to be stratified to take account of load, which is expressed, for example, as a percentage of full capacity. This could be done by the regression analysis and scatter plots of the emission rate against seemingly influential variables (e.g., emissions versus load) with load becoming a part of the required activity data.
- Adoption of results from measurements taken for other purposes may not be representative. For example, methane measurements made for safety reasons at coalmines and landfills may not reflect total emissions. In such cases, the ratio between the measured data and total emissions should be estimated for the uncertainty analysis.

➢ Uncertainties associated with an estimation of emission factors from limited measured data
- The distribution of emission factors may often differ from the normal distribution. When the distribution is already known, it is appropriate to estimate according to expert judgment, by appending a document that provides the theoretical background.

Examples of common reasons of uncertainty in activity data
➢ Interpretation of statistical differences: Statistical differences in energy balances usually represent a difference between amounts of primary fuels and amounts of fuels identified in the categories under 'final consumption' and 'in transformation'. They can give an indication of sizes of the uncertainties of the data, especially where long time series are considered.
➢ Interpretation of energy balances: Production, use, and import/export data should be consistent. If not, this may give an indication of the uncertainties.
➢ Crosschecks: It may be possible to compare two types of activity data that apply to the same source to provide an indication of uncertainty ranges. For example, the sum of vehicle fuel consumption should be commensurate with the total of fuel consumption calculated by multiplying vehicle-km by fuel consumption efficiency for all types of vehicles.
➢ Vehicle numbers and types: Some countries maintain detailed vehicle registration databases with data on vehicles by type, age, fuel type, and emission control technology, all of which can be important for a detailed bottom-up inventory of methane (CH_4) and nitrous oxide (N_2O) emissions from such vehicles. Others do not have such detailed information and this will tend to increase the uncertainty.
➢ Smuggling of fuel across borders: Imported fuel and the sum of sectoral fuel consumption may be compared as a crosscheck.
➢ Biomass fuels: Where formal markets for these fuels do not exist, consumption estimates may be much less accurate than for fuels in general.
➢ Livestock population data: Accuracy will depend on the extent and reliability of national census and survey methods, and there may be different accounting conventions for animals that do not live for a whole year.

A7.1.2.3. Methodology of Uncertainty Assessment

The *Good Practice Guidance* suggests that uncertainty is assessed through expert judgment and actual data with consideration to the sources of uncertainty indicated in section above.

A7.1.3. Methodology of Uncertainty Assessment in Japan's Inventories

A7.1.3.1. Principle of Uncertainty Assessment

The following method of uncertainty assessment is used, with regard for both convenience of the compilation and suggestions made in the *Good Practice Guidance*, in a manner that as far as possible ensures there is no deviation from assessment standards among categories.

A7.1.3.2. Separation between Emission Factors and Activity Data

The equation for estimating emissions from individual sources is generally represented as follows.

E (Emissions) = EF (Emission Factor) × A (Activity Data)

There are sources of emissions, however, where emissions are derived from stochastic equations comprising three or more parameters, and it becomes unclear which combination of parameters should be deemed as the emission factor and the activity data.

In such cases, emission factor and activity data are basically defined in accordance with the concept of emission factor described in the *Enforcement Ordinance for the Act on Promotion of Global Warming Counter Measures* (March 1999).

Example: A stochastic equation comprising three or more parameters

- Emission source: Methane emissions from a waste burial site (food scraps)
- Stochastic equation :

Volume of emissions from the source

= Carbon content in food scraps × Gas conversion rate of food scraps
× Proportion of methane in generated gas × 16/12
× Food scraps broken down during the basic period of calculation, expressed in tons

= (*Emission Factor*: Carbon content of food scraps
× Gas conversion rate of food scraps
× Proportion of methane in gas generated × 16/12)
× (*Activity Data*: Food scraps broken down during the basic period of calculation, expressed in tons)

A7.1.3.3. Uncertainty Assessment of Emission Factors

The uncertainty of emission factors is assessed using the following decision tree.

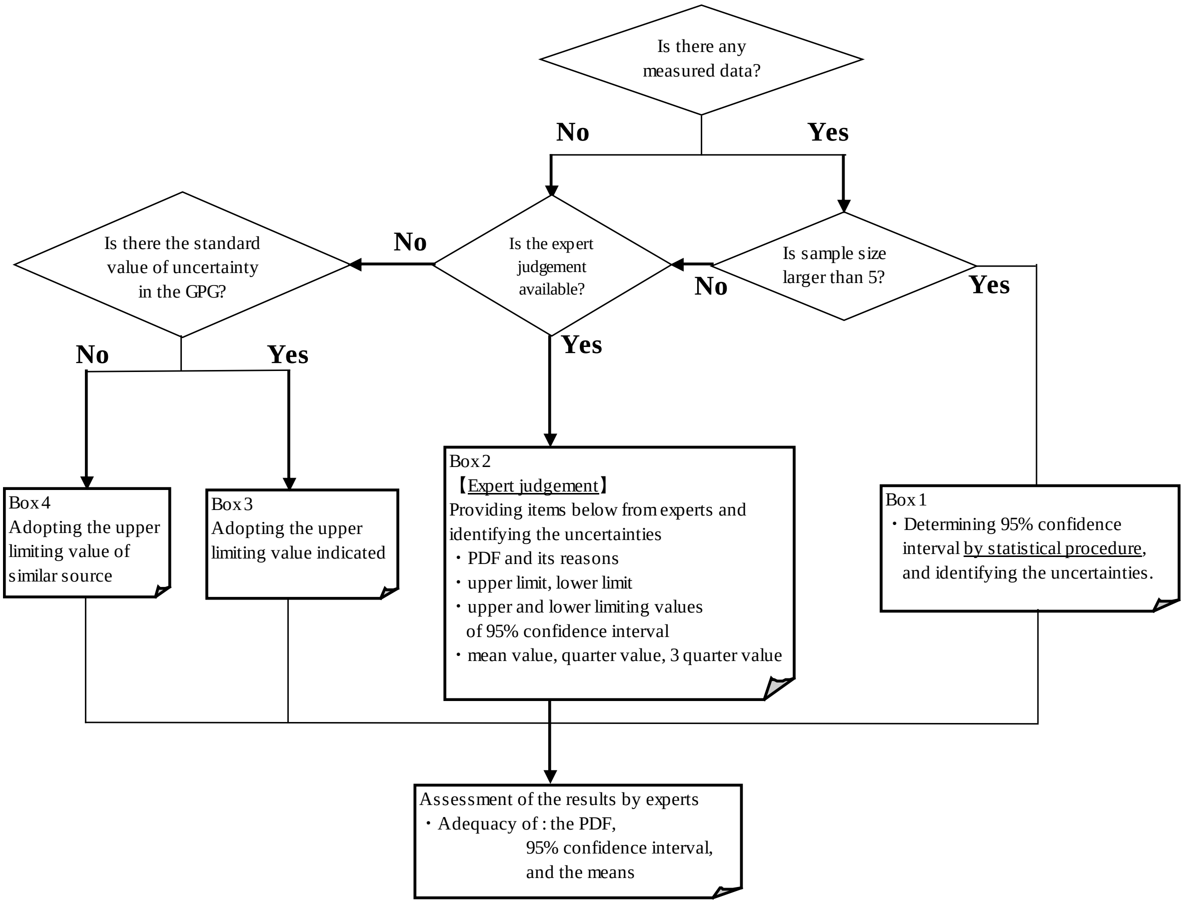

Figure A7-2 Decision tree for assessing uncertainty associated with emission factors established by the *Committee for the GHGs Emissions Estimation Methods*

> ➢ If an appropriate assessment cannot be made using the decision tree above, it may be done using a method that has been considered and deemed as appropriate. In such cases, the reason why an appropriate assessment could not be achieved using the decision tree, and the method applied, will both need to be clearly explained.

A7.1.3.3.a. Case where there is measurement data with five or more samples (Box 1)

Where data from actual measurements is available and there are five or more[1] samples, uncertainty is assessed quantitatively in accordance with the guidelines below.

Guidelines for assessment of uncertainty associated with emission factors
<u>Guideline 1</u> Where data from actual measurements is available and there are five or more samples, the central limit theorem says that the distribution of averages will follow a normal distribution curve. Assuming that all averages $\bar{x}$ and standard deviations $\sigma/\sqrt{n}$ follow a normal distribution curve, uncertainty need to be assessed on the basis of the data used to establish the emission factor only.

[1] The *Good Practice Guidance* cites “adequate samples”, but for convenience, the Secretariat of *Committee for the GHGs Estimation Methods* suggests the use of five or more.

Guideline 2

In assessing uncertainty, it is assumed that systematic error inherent to individual items of data is already a factor in the distribution. Therefore, systematic error inherent to individual items of data need not be investigated.

Guideline 3

Items that may contribute to uncertainty, but which may not be readily quantitatively assessable, should be recorded for the future investigation. If, through expert judgment, it is possible to estimate their uncertainty, the uncertainty shall be estimated in accordance with expert judgment.

a) When it is not possible to use statistical methods to derive the distribution of data used in calculating emission factors

1) Emission factor has been established by calculating a simple average of the sample data

Where the emission factor has been calculated using a simple average, it is assumed that the data used in calculating the emission factor follows a normal distribution curve. Therefore, the standard deviation of the sample is divided by the square root of the number of samples to estimate the standard deviation of the emission factor σ_{EF}, and uncertainty is calculated by finding the 95 percent confidence interval in accordance with Equation 1.1.

$$Uncertainty\ of\ Emission\ Factor(\%) = \frac{1.96 \times \sigma_{EF}}{|EF|} \quad \text{... Equation 1.1.}$$

σ_{EF} : Standard Deviation of Average
EF : Emission Factor

2) Emission factor has been calculated using a weighted average of the sample data

Where the emission factor has been derived using a weighted average of the sample data, it is assumed that the data used in calculating the emission factor follows a normal distribution. Therefore, the standard deviation σ_{EF} of the sample is derived using the equation below. Uncertainty is calculated by finding the 95 percent confidence interval of the averages in accordance with Equation 1.1. Note that the equation does not account for the uncertainty of weights w_i.

The weight applied in the weighted average, w_i ($\sum w_i = 1$)
Sample averages : $EF = \sum (w_i \times EF_i)$
Unbiased variance of sample averages :

$$\sigma_{EF}^2 = \sum_i \left\{ w_i \times \left(EF_i - \overline{EF} \right)^2 \right\} \Big/ \left(1 - \sum_i w_i^2 \right) \times \sum_i w_i^2$$

b) When the distribution of data used in calculating emission factor is derived using statistical methods

When it is possible to derive the distribution of data used in calculating the emission factor by using statistical methods, it is assumed that the data follows a normal distribution, and the uncertainty of each piece of data is estimated on the basis of section "*a) When it is not possible to use statistical methods to derive the distribution of data used in calculating emission factors*". The uncertainty of each piece of data is then determined using Equation 1.2, and the standard deviation of the emission factor σ_{EF} is calculated, to obtain the uncertainty.

> When weight averaging is done to obtain at emission factors, the emission factor *EF* is expressed as follows, where the emission factor of each sub-category is EF_i, the weight variable is A_i, and the total of weight variables is *A*.
>
> $$EF = \frac{\sum_i EF_i \times A_i}{\sum_i A_i} = \frac{\sum_i EF_i \times A_i}{A}$$
>
> Substituting the distribution of the emission factor *EF*, σ_{EF}^2 , and the distributions of the individual emission factors EF_i and individual weight variables A_i, σ_{EFi}^2 and σ_{Ai}^2 , then σ_{EF}^2 is calculated as follows, using an equation known as the Error Propagation Equation.
>
> $$\sigma_{EF}^2 = \sum_i \left\{ \left(\frac{\partial EF}{\partial EF_i} \right)^2 \sigma_{EF_i}^2 + \left(\frac{\partial EF}{\partial A_i} \right)^2 \sigma_{A_i}^2 \right\} = \sum_i \left\{ \frac{A_i^2}{A^2} \sigma_{EF_i}^2 + \frac{(EF_i - EF)^2}{A^2} \sigma_{A_i}^2 \right\}$$
>
> ... Equation 1.2.
>
> Thus, the uncertainty of the emission factor *U* is obtained using the following equation.
>
> $$U = \frac{1.96 \times \sigma_{EF}}{|EF|}$$

If experts at *Working Group on Inventory of Committee for the GHGs Emissions Estimation Methods* indicate that statistical analysis is inappropriate, even using five or more samples, then uncertainty should be assessed by expert judgment. Conversely, if an expert determines that it is possible to carry out statistical analysis, even with less than five samples, uncertainty shall be assessed statistically.

A7.1.3.3.b. Case where there is no actual measurement data, or there are less than five samples

When there is no actual measurement data, or there are less than five samples, uncertainty shall be assessed by expert judgment.

a） When expert judgment is feasible (Box 2)

1） When the distribution of the probability density function of emission factors can be obtained using expert judgment

In this case, uncertainty should be assessed in accordance with expert judgment for the following. The expert providing the expert judgment, the basis for their decision, and factors contributing to uncertainty that are excluded from consideration, should be documented, and the document should be retained.

> - Distribution and evidence
> - Upper and lower limiting values
> - Upper and lower limiting values of the 95% confidence interval
> - Mean, first, and third quartile values

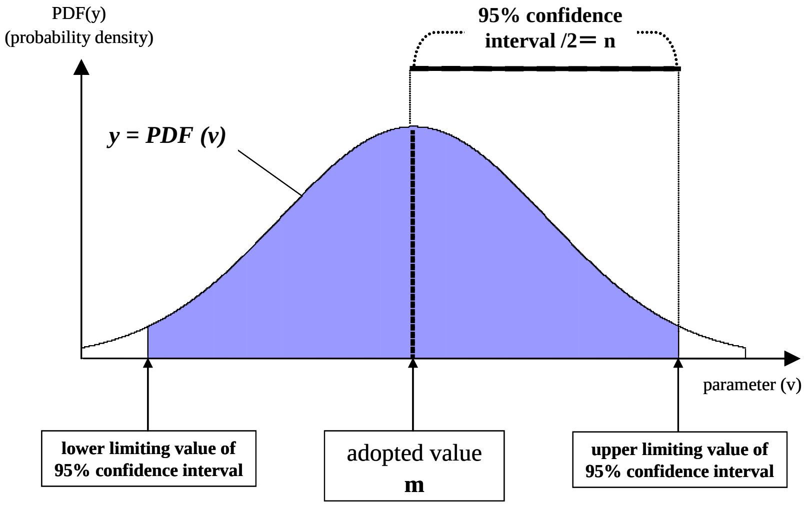

Figure A7-3 Confidence interval when the distribution of a PDF can be obtained from expert judgment

$$\text{Uncertainty of EF or A} = \frac{\text{95\% confidence interval / 2 } (n)}{|\text{ Adopted value of EF or A } (m)\ |}$$

2） *When the distribution of the probability density function of emission factors cannot be obtained using expert judgment*

Ask an expert for the upper and lower limiting values appropriate to emission factors in Japan, and draw a triangular distribution for the emission factors with the Japanese emission factor as the vertex, and such that the upper and lower limiting values of a 95 percent confidence interval correspond to the upper and lower limiting values appropriate to the Japanese emission factor (see diagram below).

If the emission factor used is larger than the upper limiting value, the emission factor should be used as the upper limiting value. If the emission factor used is smaller than the lower limiting value, the emission factor should be used as the lower limiting value.

The expert providing the expert judgment, the basis for their decision, and factors contributing to uncertainty that are excluded from consideration, should be documented, and the document should be retained.

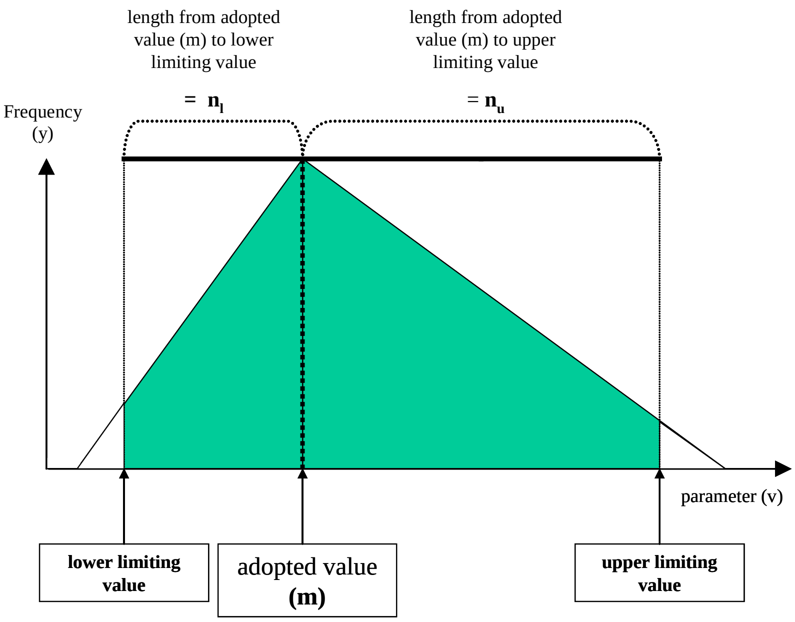

Figure A7-4 Confidence interval when the distribution of a PDF cannot be obtained from expert judgment

Uncertainty in this context is calculated using the following equation.

Uncertainty to the lower limiting value U_l [%] = – {distance to lower limiting value (n_l)/mode (m)}
Uncertainty to the upper limiting value U_u [%] = + {distance to upper limiting value (n_u)/mode (m)}
Uncertainty is expressed in the form, –○% to +●%, but in assessing overall uncertainty for Japan, the largest absolute value should be used.

b） When expert judgment is not possible

1） A standard value for uncertainty is provided in the Good Practice Guidance (Box 3)

When the *Good Practice Guidance* provides a standard value for uncertainty for a particular emission source, an estimate of uncertainty should err on the safe side, and the upper limiting value of the standard uncertainty value given in the *Good Practice Guidance* should be used.

2） No standard value for uncertainty is provided in the Good Practice Guidance (Box 4)

When the *Good Practice Guidance* does not provide a standard uncertainty for a particular emission source, the standard uncertainty given in the *Good Practice Guidance* for a similar emission source should be used for the upper limiting value.

Table A7-1 Standard uncertainty values of EFs indicated in the GPG (2000)

Category	Uncertainty of EF
1. Energy	
1.A. CO_2	5%
1.A. CH_4, N_2O	3-10%
1.A.3. Transport(CH_4, N_2O)	5%
2. Industrial Processes	
Excluding HFCs, PFCs, SF_6	1-100%
HFCs, PFCs, SF_6	5-50%
3. Solvent and Other Product Use	-*
4. Agriculture	2-60%
5. Land Use Change and Forestry	-**
6. Waste	5-100%

* Category 3: The use of organic solvents and other such products are not dealt within the GPG (2000).

** Category 5: Changes in land use and forestry are not dealt with in the GPG (2000).

A7.1.3.3.c. Methods for Combining Uncertainties of Emission Factors

The basic method for combining uncertainties is Tier 1 in the *Good Practice Guidance*. When a correlation between elements is strong, uncertainties may be combined using the Monte Carlo method (Tier 2 in the *Good Practice Guidance*).

a) Uncertainty of emission factor derived from a combination of multiple parameters

The uncertainty of an emission factor may be obtained at from the uncertainty of multiple parameters using the equation given below, in situations of the type described in the example in Section A7.1.3.2..

$$U_{EF} = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$$

U_{EF} : Uncertainties of Emission Factors [%]

U_i : Uncertainties of Parameter "i" [%]

A7.1.3.4. Uncertainty Assessment of Activity Data

The uncertainty of activity data is assessed in accordance with the decision tree depicted below.

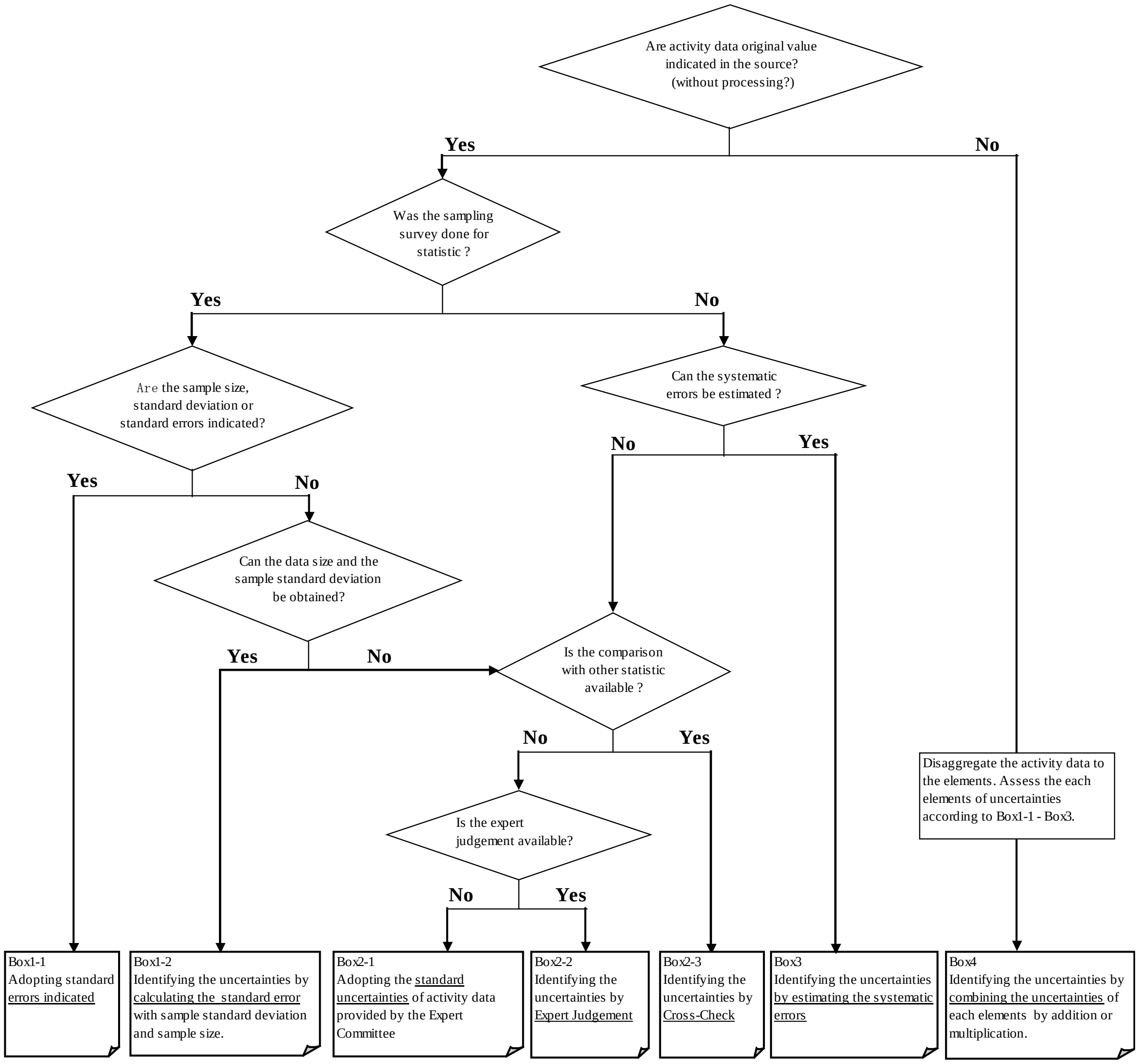

Figure A7-5 Decision tree for assessing uncertainty associated with activity data established by the *Committee for the GHGs Emissions Estimation Methods*

> ➢ If an appropriate assessment cannot be made using the decision tree above, it may be done using a method that has been considered and deemed as appropriate. The reason why an appropriate assessment could not be achieved using the decision tree, and the method applied, will both need to be clearly explained.

A7.1.3.4.a. Using statistical values for activity data

When using statistical values for activity data, uncertainty should be quantitatively assessed in accordance with the following guidelines.

Guidelines for assessment of uncertainty associated with activity data
<u>Guideline 1</u> Only the sample error needs to be considered as part of uncertainty assessment in sample surveys.

Guideline 2

In situations other than sample surveys, if it is possible to estimate a systemic error, it should be considered as part of an uncertainty assessment.

Guideline 3

In situations other than sample surveys, if it is not possible to estimate a systemic error, uncertainty should be assessed through crosschecks, or by expert judgment.

Guideline 4

Where quantitative assessment is difficult, factors that would contribute to uncertainty should be recorded for a future investigation.

a） Statistical values based on a sample survey

1） The publisher has made errors public (Box 1-1)

When the publisher of a statistical document has made the sampling errors public in the sample survey, it should be used as the uncertainty of the activity data.

2） The publisher has not made errors public (Box 1-2)

Enquire the publisher of the statistical document for the size of the sample, the sample average, and the standard deviation of the sample. Under the assumption that the distribution of the sample reproduces the distribution of the population, assessment of uncertainty from the statistical values should be done.

Uncertainty $U = \left(1.96 \times s / \sqrt{n}\right) / X_{ad}$

X_{ad} : Sample average
s : Standard deviation of sample
n : Number of items of data

If, however, distribution is asymmetrical, the uncertainty U is calculated by dividing the difference between the value of the 95 percent confidence limit furthest from X_{ad} and the average value, by X_{ad}.

Confirmation of the estimation method for Japan from values drawn from the sample survey and, as far as possible, estimation of the uncertainty associated with the estimation method should be done also (e.g., multiply the sample average of the number of head of livestock raised per farm by the number of farms).

3） Amount of data and sample standard deviation are not available, and crosschecking is possible (Box 2-3)

In the case of statistics drawn from a sample survey, where the amount of data and the sample standard deviation are not available, but it is possible to compare the relevant statistical value with multiple other statistical values, uncertainty should be assessed using the same means as in the second case described at section A1.2.3 in the page A1.7 of the *Good Practice Guidance*.

Uncertainty $U = \left(1.96 \times s\right) / X_{ap}$

X_{ap} : Value used for activity data
s : Standard deviation (data to be cross-checked)

However, if a distribution is asymmetrical, the uncertainty U may be calculated by dividing the difference between the value of the 95 percent confidence limit furthest from X_{ap} and the average value, by X_{ap}.

Also, when there is a single other statistical value only, the assessment should be done using the same method described at 2) “When the distribution of the probability density function of emission factors cannot be obtained using expert judgment” in *Section 7.1.3.3.b.*.

4） Amount of data and sample standard deviation are not available, and expert judgment is available (Box 2-2)

In the case of statistics drawn from a sample survey where the amount of data and sample standard deviation are not available, ask an expert for the upper and lower limiting values appropriate to activity data in Japan, and draw a triangular distribution for activity data (see diagram at Section A7.1.3.3.b.) with the Japanese activity data as the vertex, and such that the upper and lower limiting values of a 95 percent confidence interval correspond to the upper and lower limiting values appropriate to the Japanese activity data.

If the activity data used is larger than the upper limiting value, that activity data should be used as the upper limiting value. If the activity data used is smaller than the lower limiting value, that emission factor should be taken as the lower limiting value.

The experts providing the expert judgment, the basis for their decision, and factors contributing to uncertainty that are excluded from consideration, should be documented, and the document should be retained.

5） Amount of data and sample standard deviation are not available, and expert judgment is unavailable (Box 2-1)

The following standard values established by the *Committee for the GHGs Emissions Estimations Methods* will be used.

Table A7-2 Uncertainty of sample statistics established by the Committee for the GHGs Emissions Estimation Methods

	Fundamental statistics	Other statistics
Sample survey	50 [%]	100 [%]

The values for fundamental statistics, approved statistics, and reported statistics have been established by the Committee for the GHGs Emissions Estimation Methods, with reference to the *Good Practice Guidance* and other material. Statistics other than fundamental statistics have been deemed to be twice the fundamental statistics.

b） Statistical values not based on a sample survey

1） Systemic error can be estimated (Box 3)

Where a systemic error can be estimated, it should be estimated and used. The method by which the systemic error is calculated should be documented, and the document should be retained.

2） Systemic error cannot be estimated, and crosschecking is possible (Box 2-3)

Where systemic error cannot be estimated, but it is possible to compare the relevant statistical value with other statistical values, uncertainty should be assessed using the same means as in Case 2 described at A1.2.3 of Section A1.7 of the *Good Practice Guidance*.

3） Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is

available (Box 2-2)

Same as for "*4) Amount of data and sample standard deviation are not available, and expert judgment is available (Box 2-2)*" in Section 7.1.3.4.a.

4) Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is unavailable (Box 2-1)

The following standard values established by the Committee for the GHGs Emissions Estimation Methods should be used.

Table A7-3 Uncertainty of sample statistics established by the Committee for the GHGs Emissions Estimation Methods

	Fundamental statistics	Other statistics
Survey of total population (no rounding)	5 [%]	10 [%]
Survey of total population (rounding)	20 [%]	40 [%]

The values for fundamental statistics, approved statistics, and reported statistics have been established by the Committee for the GHGs Emissions Estimation Methods with reference to the *Good Practice Guidance* and other material. Statistics other than fundamental statistics have been deemed to be twice the fundamental statistics.

A7.1.3.4.b. Using statistical values processed as activity data (Box 3)

a) Breakdown of each element of activity data and assessment

Activity data should be broken down as shown in the following example.

- Emission source : CO_2 emission from incineration of naphtha in the chemical industry
- Stochastic equation :

Activity data for relevant emission source
= Naphtha consumption × 20% (remaining 80% is fixed in the product) [2]
- ammonia raw material

After being broken down, each element of the statistical values should be assessed for uncertainty using the method shown at section "*7.1.3.4.a. Using statistical values for activity data*".

In the example above, for elements based on survey research, such as the figure of 20%, uncertainty should be assessed on the basis of the method shown at section "*7.1.3.3. Uncertainty Assessment of Emission Factors*".

b) Combining elements

Combine each element using the sum and product methods of combination, and assess the uncertainty.

- Sum method (Rule A): Where uncertainty quantities are to be combined by addition.
  Activity data is expressed as $\boldsymbol{A_1 + A_2}$

[2] Environmental Agency, *The Estimation of CO_2 Emission in Japan*, 1992

$$U_{A-total} = \frac{\sqrt{(U_{A1} \times A_1)^2 + (U_{A2} \times A_2)^2}}{A_1 + A_2}$$

U_{An} : Uncertainty of element An [%]

- Product method: Where uncertainty quantities are to be combined by multiplication. Activity data is expressed as $\boldsymbol{A_1 \times A_2}$

$$U_A = \sqrt{U_{A1}^2 + U_{A2}^2}$$

U_{An} : Uncertainty of element An [%]

A7.1.3.5. Uncertainty Assessment of Emissions

A7.1.3.5.a. Uncertainty assessment of emissions from individual emission sources

1） Emissions estimated from emission factor and activity data

Use the product combination equation given at Tier 1 of the *Good Practice Guidance* on the results of emission factor assessment from the previous section and the activity data, and assess the uncertainty of emissions from each emission source.

$$U_{E_i} = \sqrt{U_{EF_i}^2 + U_{A_i}^2}$$

U_{Ei} : Uncertainty of emissions from emission source *i* [%]
U_{EFi} : Uncertainty of element An [%]
U_{Ai} : Uncertainty of element An [%]

2） Actual measurements taken of emissions

When emissions are derived from actual measurement, uncertainty of emissions should be assessed directly, in accordance with "*7.1.3.3. Uncertainty Assessment of Emission Factors*".

A7.1.3.5.b. Calculating uncertainty of total emissions

Combine the results of assessments of emission uncertainty for multiple emission sources to assess the uncertainty of total Japanese emissions of greenhouse gases. The uncertainty of emissions from multiple sources should be combined using the product combination equation given at Tier 1 in the *Good Practice Guidance*.

$$U_{Total} = \frac{\sqrt{(U_1 \times E_1)^2 + (U_2 \times E_2)^2 + \cdots + (U_n \times E_n)^2}}{E_1 + E_2 + \cdots + E_n}$$

U_{Total} : Uncertainty of total Japanese emissions [%]
U_i : Uncertainty of emission source *i* [%]
E_i : Emissions from emission source *i* [Gg]

When the uncertainties of emissions from multiple sources are combined, only the uncertainty of emissions should be indicated. Combination of the uncertainties for both emission factor and activity data should not be done.

A7.2. Results of Uncertainty Assessment

A7.2.1. Assumption of Uncertainty Assessment

Uncertainty Assessment is basically conducted based on the results of uncertainty assessment in Committee for the Greenhouse Gases Emissions Estimation Methods in FY2006.

A7.2.2. Uncertainty of Japan's Total Emissions

In FY2012, total net emissions in Japan were approximately 1,268 million tons (carbon dioxide equivalents). Uncertainty of total net emissions has been assessed at 2% and uncertainty introduced into the trend in total net emissions has been assessed at 1%.

Table A7-4 Uncertainty of Japan's total net emissions

IPCC Category	GHGs	Emissions / Removals [Gg-CO_2 eq.] A	[%]	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions[1)] C	rank
1A. Fuel Combustion (CO_2)	CO_2	1,221,568.1	91.0%	1%	10	0.71%	3
1A. Fuel Combustion (Stationary:CH_4,N_2O)	CH_4, N_2O	5,166.5	0.4%	27%	4	0.11%	8
1A. Fuel Combustion (Transport:CH_4,N_2O)	CH_4, N_2O	2,446.7	0.2%	400%	1	0.77%	2
1B. Fugitive Emissions from Fuels	CO_2, CH_4, N_2O	396.5	0.0%	19%	5	0.01%	9
2. Industrial Processes (CO_2,CH_4,N_2O)	CO_2, CH_4, N_2O	42,246.7	3.1%	7%	8	0.24%	7
2. Industrial Processes (HFCs,PFCs,SF_6)	HFCs, PFCs, SF_6	27,269.0	2.0%	37%	2	0.80%	1
3. Solvent & Other Product Use	N_2O	90.7	0.0%	5%	9	0.00%	10
4. Agriculture	CH_4, N_2O	23,904.8	1.8%	19%	6	0.35%	6
5. LULUCF	CO_2, CH_4, N_2O	-75,065.4	-5.6%	11%	7	0.67%	4
6. Waste	CO_2, CH_4, N_2O	20,028.6	1.5%	32%	3	0.50%	5
Total Net Emissions	(D)	1,268,052.4		(E) [2)] **2%**			

1) C = A × B / D

2) $E = \sqrt{C_1^2 + C_2^2 + \cdots}$

Hereafter, the same method for calculating uncertainty assessment has been used in each sector appearing in Table A7-4 and the following tables.

A7.2.3. Energy Sector

A7.2.3.1. Fuel Combustion (CO_2)

Carbon-Hydrogen ratio of hydrocarbons is strongly correlating with calorific value in theory, then, standard deviation of sample data of each fuel's calorific value are used for uncertainty assessment based on assumption that deviation of carbon content and that of calorific value is equal. The uncertainty of energy consumption in TJ given in the *General Energy Statistics* was assessed based on the given statistical error of solid fuels, liquid fuels, and gaseous fuels, since it was difficult to set uncertainty by fuel types and industry.

Table A7-5 Results of uncertainty assessment of fuel combustion (CO_2)

IPCC Category			GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B [1)]	rank	Combined uncertainty as % of total national emissions C	rank
1A. Fuel Combustion (CO2)	Solid Fuels	Steel Making Coal	CO_2	19,856.1	3.5%	1.2%	4%	19	0.06%	15
		Steam Coal (imported)	CO_2	255,213.7	2.0%	1.2%	2%	31	0.47%	1
		Steam Coal (indigenous)	CO_2	0.0	2.0%	1.2%	2%	31	0.00%	38
		Hard Coal	CO_2	0.0	4.5%	1.2%	5%	16	0.00%	38
		Coke	CO_2	87,408.4	1.7%	1.2%	2%	39	0.14%	6
		Coal Tar	CO_2	3,170.5	5.0%	1.2%	5%	14	0.01%	26
		Coal Briquette	CO_2	0.0	5.0%	1.2%	5%	14	0.00%	38
		Coke Oven Gas	CO_2	13,443.7	2.0%	1.2%	2%	31	0.02%	20
		Blast Furnace Gas	CO_2	42,428.0	3.8%	1.2%	4%	17	0.13%	8
		Converter Furnace Gas	CO_2	9,577.1	2.9%	1.2%	3%	20	0.02%	21
	Liquid Fuels	Crude Oil for Refinery	CO_2	0.0	0.8%	2.3%	2%	26	0.00%	38
		Crude Oil for Power Generation	CO_2	36,239.5	0.9%	2.3%	2%	25	0.07%	11
		Vitumous Mixture Fuel	CO_2	0.0	0.4%	2.3%	2%	30	0.00%	38
		NGL & Condensate	CO_2	9.1	1.6%	2.3%	3%	21	0.00%	36
		Naphtha	CO_2	399.2	0.1%	2.3%	2%	34	0.00%	32
		Reformed Material Oil	CO_2	0.0	0.1%	2.3%	2%	34	0.00%	38
		Gasoline	CO_2	130,595.0	0.03%	2.3%	2%	38	0.24%	3
		Jet Fuel	CO_2	9,770.1	1.0%	2.3%	3%	24	0.02%	23
		Kerosene	CO_2	45,574.4	0.05%	2.3%	2%	37	0.08%	10
		Gas Oil or Diesel Oil	CO_2	86,487.3	1.2%	2.3%	3%	23	0.18%	4
		Fuel Oil A	CO_2	38,477.7	1.5%	2.3%	3%	22	0.08%	9
		Fuel Oil B	CO_2	43.3	5.0%	2.3%	6%	10	0.00%	35
		Fuel Oil C	CO_2	84,810.9	0.6%	2.3%	2%	27	0.16%	5
		Lubricating Oil	CO_2	215.8	5.0%	2.3%	6%	10	0.00%	31
		Asphalt	CO_2	8,949.7	0.6%	2.3%	2%	27	0.02%	24
		Non Asphalt Heavy Oil Products	CO_2	0.0	0.6%	2.3%	2%	27	0.00%	37
		Oil Coke	CO_2	14,078.3	5.0%	2.3%	6%	10	0.06%	13
		Galvanic Furnace Gas	CO_2	124.3	2.9%	2.3%	4%	18	0.00%	33
		Refinary Gas	CO_2	31,949.4	5.0%	2.3%	6%	10	0.14%	7
		LPG	CO_2	32,046.8	0.1%	2.3%	2%	34	0.06%	14
	Gaseous Fuels	LNG	CO_2	165,148.1	0.1%	0.3%	0%	42	0.04%	17
		Indigenous Natural Gas	CO_2	2,566.1	0.6%	0.3%	1%	40	0.00%	30
		Town Gas[2)]	CO_2	87,893.3	0.5%	0.3%	1%	41	0.04%	18
		Small Scale Town Gas[2)]	CO_2	1,080.1	0.1%	0.3%	0%	42	0.00%	34
	Other Fuels	Municipal Solid Waste (Plastics)	CO_2	4,711.2	4.3%	16.0%	17%	6	0.06%	12
		Municipal Solid Waste (Waste textile)	CO_2	1,229.9	4.3%	22.4%	23%	5	0.02%	22
		Industrial Solid Waste (Waste Mineral Oil)	CO_2	79.0	4.8%	104.4%	105%	1	0.01%	28
		Industrial Solid Waste (Plastics)	CO_2	374.6	4.8%	100.0%	100%	3	0.03%	19
		Raw material and fuel use of MSW	CO_2	460.6	4.3%	16.0%	17%	6	0.01%	29
		Raw material and fuel use of ISW (Waste Mineral Oil)	CO_2	3,215.9	4.8%	104.4%	105%	1	0.27%	2
		Raw material and fuel use of ISW (Waste Plastics)	CO_2	1,519.6	4.8%	12.3%	13%	9	0.02%	25
		Raw material and fuel use of Waste tire	CO_2	945.9	4.8%	14.5%	15%	8	0.01%	27
		Fuel use of RDF and RPF	CO_2	1,475.4	42.6%	10.6%	44%	4	0.05%	16
	Sub Total			1,221,568.1			1%		0.71%	
Total Emissions			(D)	1,268,052.4			2%			

1) $B = \sqrt{a^2 + b^2}$ (Hereafter, the same method has been used in each sector appearing in TableA7-5 and following)
2) Reported in Gaseous Fuels according to the main material; LNG

A7.2.3.2. Stationary Combustion (CH_4 and N_2O)

Table A7-6 Results of uncertainty assessment of fuel combustion (CH_4 and N_2O)

IPCC Category				GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
1A. Fuel Combustion (Stationary: CH4, N2O)	Solid fuels, liquid fuels, gaseous fuels and biomass			CH_4	683.8	— [1)]	— [1)]	47%	12	0.03%	2
				N_2O	4,063.5	— [1)]	— [1)]	33%	15	0.11%	1
	Other fuels (part of 6C Waste incineration)	Municipal Solid Waste		CH_4	2.5	—	—	101%	7	0.00%	10
				N_2O	290.9	—	—	42%	13	0.01%	3
		Industrial Solid Waste		CH_4	0.2	111.5%	100.0%	150%	2	0.00%	15
				N_2O	2.9	58.8%	100.0%	116%	4	0.00%	7
		Raw material and fuel use of MSW		CH_4	0.0	179.4%	10.0%	180%	1	0.00%	17
				N_2O	0.0	111.2%	10.0%	112%	5	0.00%	17
		Raw material and fuel use of ISW	Waste Oil (total)	CH_4	0.5	—	—	74%	10	0.00%	9
				N_2O	13.1	—	—	41%	14	0.00%	11
			Waste Plastics	CH_4	3.5	91.7%	10.0%	92%	8	0.00%	14
				N_2O	4.5	29.7%	10.0%	31%	17	0.00%	6
			Waste Wood	CH_4	74.4	80.2%	100.0%	128%	3	0.01%	4
				N_2O	12.4	45.3%	100.0%	110%	6	0.00%	5
		Raw material and fuel use of Waste tire		CH_4	0.7	—	—	91%	9	0.00%	13
				N_2O	4.9	—	—	26%	18	0.00%	12
		Fuel use of RDF and RPF		CH_4	0.2	—	—	49%	11	0.00%	16
				N_2O	8.5	—	—	33%	16	0.00%	8
	Sub Total				5,166.5			27%		0.11%	
Total Emissions				(D)	1,268,052.4			2%			

1) Because "—" means aggregation of detailed sub-categories, uncertainties of EF/RF and AD can not be calculated for this level of disaggregation of categories.
2) Regarding Fuel use of RDF and RPF, uncertainty of "RDF" has been used.

A7.2.3.3. Mobile Combustion (CH_4 and N_2O)

Table A7-7 Results of uncertainty assessment of mobile combustion (CH_4 and N_2O)

IPCC Category		GHGs	Emissions / Removals [Gg-CO_2 eq.]	EF/RF Uncertainty [%]	AD Uncertainty [%]	Combined Uncertainty [%]	rank	Combined uncertainty as % of total national emissions	rank
			A	a	b	B		C	
1A.Fuel Combustion (Transport: CH4, N2O)	a. Civil Aviation[1]	CH_4	5.0	200.0%	10.0%	200%	**4**	0.00%	6
		N_2O	96.3	10000.0%	10.0%	10000%	**1**	0.76%	**1**
	b. Road Transportation	CH_4	127.7	—	50.0%	64%	6	0.01%	**4**
		N_2O	2,035.5	—	50.0%	71%	**5**	0.11%	**2**
	c. Railways	CH_4	0.6	—	—	10%	8	0.00%	8
		N_2O	70.4	—	—	11%	7	0.00%	7
	d. Navigation	CH_4	21.3	200.0%	13.0%	200%	**3**	0.00%	**5**
		N_2O	89.8	1000.0%	13.0%	1000%	**2**	0.07%	**3**
	Sub Total		2,446.7			400%		0.77%	
Total Emissions		(D)	1,268,052.4			2%			

1) CO_2 emissions from 1A Fuel Combustion (Transport) have been reported in Table A7-4.

A7.2.3.4. Fugitive Emissions from Fuel

Table A7-8 Results of uncertainty assessment of fugitive emissions from fuel

IPCC Category					GHGs	Emissions / Removals [Gg-CO_2 eq.]	EF/RF Uncertainty [%]	AD Uncertainty [%]	Combined Uncertainty [%]	rank	Combined uncertainty as % of total national emissions	rank
						A	a	b	B		C	
1B. Fugitive Emissions from Fuels	1. Solid Fuels	a. Coal Mining	i. Underground Mines	Mining Activities	CH_4	16.5	—	–	5%	24	0.00%	12
				Post-Mining Activities	CH_4	18.2	200.0%	10.0%	200%	**1**	0.00%	**2**
			ii. Surface Mines	Mining Activities	CH_4	11.6	200.0%	10.0%	200%	**1**	0.00%	**3**
				Post-Mining Activities	CH_4	1.0	200.0%	10.0%	200%	**1**	0.00%	11
	2. Oil and Natural Gas	a. Oil		i. Exploration	CO_2	0.01	25.0%	10.0%	27%	7	0.00%	20
					CH_4	0.01	25.0%	10.0%	27%	6	0.00%	21
					N_2O	0.00002	25.0%	10.0%	27%	**4**	0.00%	24
				ii. Production	CO_2	0.08	25.0%	5.0%	25%	8	0.00%	17
					CH_4	8.6	25.0%	5.0%	25%	8	0.00%	9
				iii. Transport	CO2	0.0041	25.0%	5.0%	25%	8	0.00%	22
					CH_4	1.3	25.0%	5.0%	25%	8	0.00%	14
				iv. Refining / Storage	CH_4	13.5	25.0%	0.9%	25%	20	0.00%	7
		b. Natural Gas		ii. Production / Processing	CO_2	0.4	25.0%	–	25%	21	0.00%	16
					CH_4	243.6	25.0%	–	25%	22	0.00%	**1**
				iii. Transmission	CH_4	23.2	25.0%	10.0%	27%	**4**	0.00%	**4**
				iv. Distribution	CH_4	16.7	25.0%	–	21%	23	0.00%	6
		c. Venting and Flaring	Venting	i. oil	CO_2	0.0	25.0%	5.0%	25%	8	0.00%	23
					CH_4	8.2	25.0%	5.0%	25%	8	0.00%	10
			Flaring	i. oil	CO_2	18.8	25.0%	5.0%	25%	8	0.00%	**5**
					CH_4	0.81	25.0%	5.0%	25%	8	0.00%	15
					N_2O	0.056	25.0%	5.0%	25%	8	0.00%	18
				ii. Gas	CO_2	12.4	25.0%	5.0%	25%	8	0.00%	8
					CH_4	1.6	25.0%	5.0%	25%	8	0.00%	13
					N_2O	0.045	25.0%	5.0%	25%	8	0.00%	19
	Sub Total					396.5			19%		0.01%	
Total Emissions					(D)	1,268,052.4			2%			

A7.2.4. Industrial Processes

A7.2.4.1. CO_2, CH_4 and N_2O

For emissions sources with actual data available for emission factors, the emission factor dataset is deemed to be a sample of the total dataset, and the uncertainty assessment is achieved statistically. It is not a synthesis of the uncertainties of measured error of emissions from each operating site.

Table A7-9 Results of uncertainty assessment of industrial processes (CO_2, CH_4 and N_2O)

IPCC Category				GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
2. Industrial Processes	A. Mineral Products	1. Cement Production		CO_2	25,059.6	3.0%	10.0%	10%	10	0.21%	1
		2. Lime Production		CO_2	5,670.1	15.0%	5.0%	16%	9	0.07%	3
		3. Limestone & Dolomite Use	Limestone	CO_2	6,391.5	16.4%	4.8%	17%	7	0.09%	2
			Dolomite	CO_2	1,642.5	3.5%	3.9%	5%	12	0.01%	8
		4. Soda Ash Production and Use		CO_2	142.3	15.0%	6.3%	16%	8	0.00%	9
	B. Chemical Industries	1. Ammonia Production		CO_2	1,837.6	22.5%	5.0%	23%	6	0.03%	5
		Chemical Industries other than Anmonia		CO_2	578.1	77.2%	5.0%	77%	4	0.04%	4
		2. Nitric Acid		N_2O	474.6	46.0%	5.0%	46%	5	0.02%	6
		3. Adipic Acid		N_2O	156.8	9.0%	2.0%	9%	11	0.00%	11
		whole of Chemical Industires		CH_4	104.33	98.5%	5.0%	99%	3	0.01%	7
	C. Metal Production	1. Iron and steel		CO_2	174.2	–	–	5%	13	0.00%	12
				CH_4	12.5	163.0%	5.0%	163%	1	0.00%	10
		2. Ferroalloy		CH_4	2.7	163.0%	5.0%	163%	1	0.00%	13
	Sub Total				42,246.7			7%		0.24%	
Total Emissions				(D)	1,268,052.4			2%			

A7.2.4.2. F-gases

Table A7-10 Results of uncertainty assessment of industrial processes (F-gases)

IPCC Category					GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
2. Industrial Processes (F-gas)	C. Metal Production	3. Aluminium			PFCs	9.0	33.0%	5.0%	33%	30	0.00%	21
		4. SF6 Used in Aluminium and Magnesium Foundries[1]			SF_6	191.2	–	5.0%	5%	32	0.00%	19
					HFCs	1.2	–	5.0%	5%	32	0.00%	24
	E. Production of F-gas	1. By-product Emissions (HCFC-22)			HFCs	14.0	2.0%	5.0%	5%	31	0.00%	23
		2. Fugitive Emissions			HFCs	78.4	100.0%	10.0%	100%	1	0.01%	14
					PFCs	122.2	100.0%	10.0%	100%	1	0.01%	10
					SF_6	129.1	100.0%	10.0%	100%	1	0.01%	9
	F. Consumption of F-gas	1. Refrigeration and Air Conditioning Equipment	Domestic Refrigerator	manufacturing	HFCs	330.5	50.0%	40.0%	64%	6	0.02%	8
				stock	HFCs	IE	50.0%	40.0%	64%	6	0.00%	25
				disposal	HFCs	IE	–	40.0%	40%	20	0.00%	25
			Commercial Refrigerator	manufacturing	HFCs	15,010.4	50.0%	40.0%	64%	6	0.76%	1
				stock	HFCs	IE	50.0%	40.0%	64%	6	0.00%	25
				disposal	HFCs	IE	–	40.0%	40%	20	0.00%	25
			Stationary Air-Conditioning	manufacturing	HFCs	4,138.5	50.0%	40.0%	64%	6	0.21%	2
				stock	HFCs	IE	50.0%	40.0%	64%	6	0.00%	25
				disposal	HFCs	IE	–	40.0%	40%	20	0.00%	25
			Mobile Air-Conditioning	manufacturing	HFCs	2,441.0	50.0%	40.0%	64%	6	0.12%	3
				stock	HFCs	IE	50.0%	40.0%	64%	6	0.00%	25
				disposal	HFCs	IE	–	40.0%	40%	20	0.00%	25
		2. Foam Blowing		manufacturing	HFCs	134.4	50.0%	50.0%	71%	4	0.01%	13
				stock	HFCs	160.0	50.0%	50.0%	71%	4	0.01%	12
		3. Fire Extinguisher		manufacturing	HFCs	7.0	50.0%	40.0%	64%	6	0.00%	20
		4. Aerosols / MDI	Aerosols	manufacturing	HFCs	75.8	–	40.0%	40%	20	0.00%	18
				stock	HFCs	305.6	–	40.0%	40%	20	0.01%	11
			MDI	manufacturing	HFCs	4.6	–	40.0%	40%	20	0.00%	22
				stock	HFCs	148.6	–	40.0%	40%	20	0.00%	16
		5. Solvents			PFCs	1,266.5	–	40.0%	40%	20	0.04%	5
		7. Semiconductor Manufacture			HFCs	75.8	50.0%	40.0%	64%	6	0.00%	17
					PFCs	1,360.6	50.0%	40.0%	64%	6	0.07%	4
					SF_6	511.2	50.0%	40.0%	64%	6	0.03%	7
		8. Electrical Equipment		manufacturing	SF_6	153.0	30.0%	40.0%	50%	19	0.01%	15
				stock	SF_6	600.6	50.0%	40.0%	64%	6	0.03%	6
		9. Other - Railway Silicon Rectifiers			PFCs	0.0	–	40.0%	40%	20	0.00%	25
	Sub Total					27,269.0			37%		0.80%	
Total Emissions					(D)	1,268,052.4			2%			

1) Uncertainty of SF_6 emissions from 2.C.4 Magnesium Foundries applies the same value as that of 2.C.3 Aluminium.

A7.2.5. Solvents and Other Product Use

Table A7-11 Results of uncertainty assessment of solvent and other product use

IPCC Category			GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
3. Solvent and Other Product Use	D. Other	Anaesthesia	N_2O	90.7	–	5.0%	5%	1	0.00%	1
	Sub Total			90.7			5%		0.00%	
Total Emissions			(D)	1,268,052.4			2%			

A7.2.6. Agriculture

Table A7-12 Results of uncertainty assessment of agriculture

IPCC Category				GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
4. Agriculture	A. Enteric Fermentation	Dairy Cattle		CH_4	3,007.7	—	5.0%	15%	63	0.04%	13
		Non-Dairy Cattle		CH_4	3,114.4	—	5.0%	19%	62	0.05%	12
		Buffalo		CH_4	0.10	50.0%	100.0%	112%	44	0.00%	55
		Sheep		CH_4	1.23	50.0%	100.0%	112%	44	0.00%	40
		Goat		CH_4	1.19	50.0%	100.0%	112%	44	0.00%	41
		Swine		CH_4	223.3	50.0%	0.9%	50%	58	0.01%	20
		Horse		CH_4	30.8	50.0%	100.0%	112%	44	0.00%	24
	B. Manure Management	Dairy Cattle		CH_4	1,796.305	—	—	78%	54	0.11%	**4**
				N_2O	925.5	—	—	91%	52	0.07%	10
		Non-Dairy Cattle		CH_4	115.806	—	—	73%	56	0.01%	21
				N_2O	964.0	—	—	125%	42	0.10%	**5**
		Buffalo		CH_4	0.004	100.0%	100.0%	141%	31	0.00%	63
				N_2O	0.005	100.0%	100.0%	141%	31	0.00%	62
		Swine		CH_4	142.314	—	0.9%	106%	48	0.01%	18
				N_2O	1,283.4	—	0.9%	92%	51	0.09%	7
		Poultry (Hen, Broiler)		CH_4	63.239	—	12.4%	54%	57	0.00%	25
				N_2O	538.5	—	12.4%	80%	53	0.03%	14
		Sheep		CH_4	0.083	100.0%	100.0%	141%	31	0.00%	54
				N_2O	0.1	100.0%	100.0%	141%	31	0.00%	57
		Goat		CH_4	0.051	100.0%	100.0%	141%	31	0.00%	59
				N_2O	0.1	100.0%	100.0%	141%	31	0.00%	58
		Horse		CH_4	3.555	100.0%	100.0%	141%	31	0.00%	30
				N_2O	0.4	100.0%	100.0%	141%	31	0.00%	45
	C. Rice Cultivation	Continuously Flooded		CH_4	191.1	116.3%	0.3%	116%	43	0.02%	17
		Intermittently Flooded	Straw amendment	CH_4	3,763.0	—	0.3%	32%	61	0.09%	6
			Various compost	CH_4	1,038.1	—	0.3%	32%	60	0.03%	15
			No-amendment	CH_4	488.2	—	0.3%	46%	59	0.02%	16
	D. Agricultural Soils	1. Direct Soil Emissions	Synthetic Fertilizers	N_2O	1,247.4	—	—	139%	39	0.14%	**2**
			Animal Waste Applied to Soils	N_2O	1,407.4	—	—	152%	30	0.17%	**1**
			N-Fixing Crops	N_2O	77.3	—	—	99%	49	0.01%	22
			Crop residues	N_2O	479.1	—	—	211%	16	0.08%	8
			Organic soil	N_2O	115.8	—	—	712%	**1**	0.06%	11
		2. Pasture, Range and Paddock Manure		N_2O	50.3	—	—	133%	40	0.01%	23
		3. Indirect Emissions	Atmospheric Deposition	N_2O	1,221.6	—	—	75%	55	0.07%	9
			N Leaching & Run-off	N_2O	1,541.0	—	—	97%	50	0.12%	**3**
	F. Field Burning of Agricultural Residue	1. Cereals	Wheat	CH_4	5.4	—	—	186%	20	0.00%	28
				N_2O	1.2	—	—	185%	24	0.00%	36
			Barley	CH_4	1.1	—	—	185%	22	0.00%	37
				N_2O	0.3	—	—	187%	18	0.00%	47
			Maize	CH_4	29.2	418.0%	50.0%	421%	7	0.01%	19
				N_2O	6.2	423.0%	50.0%	426%	**3**	0.00%	27
			Oats	CH_4	0.5	—	—	156%	28	0.00%	43
				N_2O	0.4	—	—	170%	27	0.00%	44
			Rye	CH_4	0.024	—	—	130%	41	0.00%	60
				N_2O	0.012	—	—	154%	29	0.00%	61
			Rice	CH_4	16.3	178.0%	50.0%	185%	23	0.00%	26
				N_2O	4.6	175.0%	50.0%	182%	26	0.00%	29
		2. Pulse	Peas	CH_4	0.08	481.0%	20.0%	481%	**2**	0.00%	48
				N_2O	0.05	423.0%	20.0%	423%	**5**	0.00%	51
			Soybeans	CH_4	1.53	176.0%	50.0%	183%	25	0.00%	33
				N_2O	1.01	182.0%	50.0%	189%	17	0.00%	38
			Other (Adzuki beans)	CH_4	0.30	179.0%	50.0%	186%	21	0.00%	46
				N_2O	0.18	180.0%	50.0%	187%	19	0.00%	50
			Other (kidney beans)	CH_4	0.04	418.0%	50.0%	421%	7	0.00%	52
				N_2O	0.03	418.0%	50.0%	421%	7	0.00%	56
			Other (peanuts)	CH_4	0.08	418.0%	50.0%	421%	7	0.00%	49
				N_2O	0.03	418.0%	50.0%	421%	7	0.00%	53
		3. Tuber & Roots	Potatoes	CH_4	0.4	418.0%	20.0%	418%	15	0.00%	39
				N_2O	0.5	419.0%	20.0%	419%	14	0.00%	35
			Other: Sugarbeet	CH_4	1.1	417.0%	50.0%	420%	13	0.00%	31
				N_2O	1.0	419.0%	50.0%	422%	6	0.00%	32
		4. Sugar Cane		CH_4	0.6	418.0%	50.0%	421%	7	0.00%	34
				N_2O	0.2	423.0%	50.0%	426%	**3**	0.00%	42
	Sub Total				23,904.8			19%		0.35%	
Total Emissions				(D)	1,268,052.4			2%			

A7.2.7. LULUCF

Table A7-13 Results of uncertainty assessment of LULUCF

IPCC Category			GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank [1]
5. Land Use, Land Use Change and Forestry	A. Forest Land	1. Forest Land remaining Forest Land	CO_2	-77,324.2	–	–	11%	13	-21.66%	**1**
		2. Land converted to Forest Land	CO_2	-348.6	–	–	38%	7	-0.34%	**5**
			CH_4	1.6	25.0%	37.0%	45%	**5**	0.00%	13
			N_2O	0.7	28.6%	37.0%	108%	**1**	0.00%	12
	B. Cropland	1. Cropland remaining Cropland	CO_2	1,461.2	–	–	19%	12	0.7%	**4**
		2. Land converted to Cropland	CO_2	180.0	–	–	25%	11	0.12%	9
			CH_4	NE,NO	–	–	–	–	–	–
			N_2O	4.0	–	–	82%	**3**	0.01%	11
	C. Grassland	1. Grassland remaining Grassland	CO_2	NA,NO,NE	–	–	–	–	–	–
		2. Land converted to Grassland	CO_2	-116.0	–	–	97%	**2**	-0.29%	8
			CH_4	NE,NO	–	–	–	–	–	–
			N_2O	NE,NO	–	–	–	–	–	–
	D. Wetlands	1. Wetlands remaining Wetlands	CO_2	NO,NE	–	–	–	–	–	–
		2. Land converted to Wetlands	CO_2	31.8	–	–	29%	10	0.02%	10
			CH_4	NE,NO	–	–	–	–	–	–
			N_2O	NE,NO	–	–	–	–	–	–
	E. Settlements	1. Settlements remaining Settlements	CO_2	-968.6	–	–	35%	8	-0.86%	**3**
		2. Land converted to Settlements	CO_2	1,476.9	–	–	31%	9	1.16%	**2**
			CH_4	NO	–	–	–	–	–	–
			N_2O	NO	–	–	–	–	–	–
	F. Other Land	1. Other Land remaining Other Land	CO_2	–	–	–	–	–	–	–
		2. Land converted to Other Land	CO_2	289.0	–	–	40%	6	0.30%	7
			CH_4	NO	–	–	–	–	–	–
			N_2O	NO	–	–	–	–	–	–
	G. Other	CO_2 emissions from agricultural lime application	CO_2	246.8	–	–	51%	**4**	0.32%	6
	Sub Total			-75,065.4			11%		21.72%	
Total Emissions			(D)	1,268,052.4			2%			

1) Numbers of the rank have been assessed based on the absolute values of "Combined uncertainty as % of total national emissions".

A7.2.8. Waste

Table A7-14 Results of uncertainty assessment of waste

IPCC Category				GHGs	Emissions / Removals [Gg-CO_2 eq.] A	EF/RF Uncertainty [%] a	AD Uncertainty [%] b	Combined Uncertainty [%] B	rank	Combined uncertainty as % of total national emissions C	rank
6. Waste	A. Solid Waste Disposal on Land	1. Managed Landfill Sites	Food waste[1]	CH_4	258.0	42.4%	32.4%	53%	30	0.01%	14
			Paper	CH_4	1,303.3	42.4%	42.7%	60%	26	0.06%	**5**
			Textile	CH_4	90.2	43.8%	42.9%	61%	25	0.00%	22
			Wood	CH_4	904.2	42.5%	56.6%	71%	21	0.05%	7
			Digested Sewage Sludge	CH_4	19.4	44.2%	32.0%	55%	28	0.00%	30
			Other Sewage Sludge	CH_4	99.8	44.2%	32.0%	55%	28	0.00%	23
			Human Waste Sludge	CH_4	51.0	44.2%	32.6%	55%	27	0.00%	26
			Waterworks Sludge	CH_4	23.5	108.6%	31.7%	113%	8	0.00%	27
			Organic Sludge from Manufacture	CH_4	127.9	54.0%	33.4%	63%	24	0.01%	19
			Livestock Waste	CH_4	20.9	46.9%	49.4%	68%	23	0.00%	29
		3. Other	Inappropriate Disposal	CH_4	42.3	42.5%	66.8%	79%	16	0.00%	24
	B. Wastewater Handling	1. Industrial Wastewater		CH_4	102.7	60.0%	37.4%	71%	22	0.01%	20
				N_2O	120.8	300.0%	51.1%	304%	**1**	0.03%	11
		2. Domestic and Commercial Wastewater	Sewage Treatment Plants	CH_4	254.3	30.9%	10.4%	33%	32	0.01%	18
				N_2O	481.3	145.7%	10.4%	146%	**5**	0.06%	6
			Domestic Wastewater Treatment Facilities[2]	CH_4	690.4	86.8%	10.0%	87%	14	0.05%	8
				N_2O	528.5	71.0%	10.0%	72%	20	0.03%	10
			Human-Waste Treatment Facilities	CH_4	10.4	100.0%	12.3%	101%	11	0.00%	31
				N_2O	5.1	100.0%	33.9%	106%	9	0.00%	33
			Degradation of Domestic Wastewater in Nature	CH_4	406.0	—	—	76%	17	0.02%	12
				N_2O	39.2	—	—	76%	17	0.00%	25
	C. Waste Incineration	Municipal Solid Waste[3]	Plastics	CO_2	2,517.4	4.3%	16.0%	17%	35	0.03%	9
			Waste textile	CO_2	657.2	4.3%	22.4%	23%	34	0.01%	13
				CH_4	1.3	—	—	101%	12	0.00%	35
				N_2O	155.5	—	—	42%	31	0.01%	21
		Industrial Solid Waste[4), 5)]	Waste mineral oil	CO_2	3,662.7	4.8%	104.4%	105%	10	0.30%	**1**
			Plastics	CO_2	3,497.3	4.8%	100.0%	100%	13	0.28%	**2**
				CH_4	6.1	111.5%	100.0%	150%	**4**	0.00%	32
				N_2O	1,458.5	58.8%	100.0%	116%	7	0.13%	**4**
		Specially Contorolled Industrial Solid Waste		CO_2	1,665.4	—	—	167%	**2**	0.22%	**3**
				CH_4	1.0	—	—	142%	6	0.00%	34
				N_2O	13.8	—	—	159%	**3**	0.00%	28
	D. Oher	Decomposition of petroleum-derived surface-active agent		CO_2	515.1	—	—	25%	33	0.01%	15
		Composting of Organic Waste		CH_4	164.8	—	—	74%	19	0.01%	17
				N_2O	146.0	—	—	86%	15	0.01%	16
	Sub Total				20,028.6			32%		0.50%	
Total Emissions				(D)	1,268,052.4			2%			

1) Regarding 6A1, uncertainty of "Anaerobic landfill", which is the largest source under this sub-category, has been used.
2) Regarding 6A2, uncertainty of "Gappei-shori johkasou", which is the largest source under this sub-category, has been used.
3) Regarding CH_4 of 6C MSW, uncertainty of "Semi-Continuous Incinerator" has been used.
4) Regarding CH_4 of 6C ISW, uncertainty of "Waste Paper and Waste Wood" has been used.
5) Regarding N_2O of 6C ISW, uncertainty of "Waste Plastics" has been used.

A7.2.9. Consideration of the results

The result of uncertainty assessment shows that Japan's uncertainty of total net emissions is approximately 2%. This value is relatively smaller compared to 21.3% of UK indicated in the *Good Practice Guidance.* It is attributed to the fact that the ratio of Japan's N_2O emission from "4.D.1. Agricultural Soils (Direct Soil Emissions)" to the national total emissions is small compared to that of UK (the ratios of Japan and UK reported in their inventories submitted in 2003 were 0.28% and 4.1%, respectively).

Below are the results of sensitivity analysis with N_2O emissions from this source, uncertainty of emission factor and national total emissions (calculation used the reported values of inventories submitted in 2003).

Table A7-15 Sensitivity analysis on N_2O emissions from "4.D. Agricultural soils 1 Direct emissions"

	N_2O emissions [Gg-CO_2eq.]	Uncertainty of EF	Uncertainty of total emissions	Note
Original	3,597.58	129.9%	2.4%	2001 Emissions contained in the GHG inventory submitted in 2003.
Case 1	3,597.58	500%	2.6%	EF uncertainty was assumed to be same as UK's case.
Case 2	71,951.53	129.9%	4.8%	Emissions were assumed to be approximately 5% of national total emissions in 2001.

A7.2.10. Issues in Uncertainty Assessment

- According to the method indicated in the *Revised 1996 IPCC Guidelines*, only emission sources of which emissions had already been calculated were the subject of uncertainty assessment. No assessment has been made for emission sources not estimated (NE), or of those portions unconfirmed in emission sources for which only partial calculation has been done (PART). Therefore, it should be remembered that the uncertainty of total emissions prepared by compiling the uncertainty of emissions from each source, does not depict the uncertainty of inventory in the context of the realities of emissions.
- In the sources recalculated, consideration is needed whether to re-assess the uncertainties or not.
- Where it was not possible to carry out a statistical assessment of the uncertainty of activity data, the values were derived from those established by the Committee for the GHGs Emissions Estimations Methods, which have established the uncertainty values in relation to whether the data were derived from specified statistics, or whether they were obtained from total population surveys. But further consideration needs to be given to improve the appropriateness of this approach.
- In carrying out a statistical assessment of uncertainty, it was assumed that the averages of all samples followed a normal distribution. In some cases, however, it means that the emission factor or activity data could, in fact, be negative. Emissions can only be positive under the present IPCC guidelines, so further consideration would need to be given for the possibility to assume that the emission factor or activity data follows some other distribution.

- Consideration on application of probability density function (PDF) with Monte-Carlo analysis is further issue. Further consideration on analysis with more disaggregated sources or each coefficients are needed.
- The number of decimal places to be used when depicting uncertainty was set as follows for the uncertainty assessments conducted, but as the precision of uncertainty assessment varies between emission sources, further consideration needs to be given to the number of decimal places that are effective in uncertainty assessment.

  1) Uncertainty of emission factor is given to one decimal place.
  2) Uncertainty of activity data is also given to one decimal place.
  3) Uncertainty of emissions is given as an integer. (Proportion of total emissions attributable to the uncertainty of a particular source = two decimal places.)

A7.2.11. Reference Material

Results of the uncertainty assessment for the latest reported year in accordance with Table 6.1 of the *GPG (2000)* are indicated below.

Table A7-16 Results of the uncertainty assessment

A					B	C	D	E	F	G	H	I	J	K	L	M
IPCC source category					Gas	Base year emissions / removals	2012 emissions / removals	Activity data uncertainty	EF or RF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2012	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF or RF 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	See footnote 1.	D/ΣC	I*F	J*E*√2	(K^2+L^2)^1/2
						Gg-CO_2 eq.	Gg-CO_2 eq.	%	%	%	%	%	%	%	%	%
Total						1,167,502.21	1,268,052.37				2%					1%
1A. Fuel Combustion (CO2)	Solid Fuels	Steel Making Coal			CO_2	9,244.05	19,856.05	1.2%	3.5%	4%	0.1%	0.8%	1.7%	0.0%	0.0%	0.0%
		Steam Coal (imported)			CO_2	88,401.29	255,213.66	1.2%	2.0%	2%	0.5%	13.6%	21.9%	0.3%	0.4%	0.5%
		Steam Coal (indigenous)			CO_2	20,125.86	0.00	1.2%	2.0%	2%	0.0%	-1.9%	0.0%	0.0%	0.0%	0.0%
		Hard Coal			CO_2	0.00	0.00	1.2%	4.5%	5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Coke			CO_2	117,790.21	87,408.41	1.2%	1.7%	2%	0.1%	-3.5%	7.5%	-0.1%	0.1%	0.1%
		Coal Tar			CO_2	3,173.39	3,170.48	1.2%	5.0%	5%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%
		Coal Briquette			CO_2	310.20	0.00	1.2%	5.0%	5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Coke Oven Gas			CO_2	15,976.84	13,443.71	1.2%	2.0%	2%	0.0%	-0.3%	1.2%	0.0%	0.0%	0.0%
		Blast Furnace Gas			CO_2	43,496.15	42,427.96	1.2%	3.8%	4%	0.1%	-0.4%	3.6%	0.0%	0.1%	0.1%
		Converter Furnace Gas			CO_2	9,303.92	9,577.11	1.2%	2.9%	3%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%
	Liquid Fuels	Crude Oil for Refinery			CO_2	1.91	0.00	2.3%	0.8%	2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Crude Oil for Power Generation			CO_2	58,483.38	36,239.49	2.3%	0.9%	2%	0.1%	-2.3%	3.1%	0.0%	0.1%	0.1%
		Vitumous Mixture Fuel			CO_2	0.00	0.00	2.3%	0.4%	2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		NGL & Condensate			CO_2	1,380.12	9.08	2.3%	1.6%	3%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
		Naphtha			CO_2	1,297.82	399.22	2.3%	0.1%	2%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
		Reformed Material Oil			CO_2	0.00	0.00	2.3%	0.1%	2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Gasoline			CO_2	103,913.39	130,595.05	2.3%	0.0%	2%	0.2%	1.5%	11.2%	0.0%	0.4%	0.4%
		Jet Fuel			CO_2	9,140.23	9,770.08	2.3%	1.0%	3%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%
		Kerosene			CO_2	64,049.60	45,574.42	2.3%	0.1%	2%	0.1%	-2.1%	3.9%	0.0%	0.1%	0.1%
		Gas Oil or Diesel Oil			CO_2	98,847.94	86,487.32	2.3%	1.2%	3%	0.2%	-1.8%	7.4%	0.0%	0.2%	0.2%
		Fuel Oil A			CO_2	74,790.57	38,477.71	2.3%	1.5%	3%	0.1%	-3.7%	3.3%	-0.1%	0.1%	0.1%
		Fuel Oil B			CO_2	1,865.42	43.28	2.3%	5.0%	6%	0.0%	-0.2%	0.0%	0.0%	0.0%	0.0%
		Fuel Oil C			CO_2	143,715.21	84,810.92	2.3%	0.6%	2%	0.2%	-6.1%	7.3%	0.0%	0.2%	0.2%
		Lubricating Oil			CO_2	67.74	215.83	2.3%	5.0%	6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Asphalt			CO_2	5,510.07	8,949.70	2.3%	0.6%	2%	0.0%	0.3%	0.8%	0.0%	0.0%	0.0%
		Non Asphalt Heavy Oil Products			CO_2	7.76	0.00	2.3%	0.6%	2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Oil Coke			CO_2	9,505.00	14,078.33	2.3%	5.0%	6%	0.1%	0.3%	1.2%	0.0%	0.0%	0.0%
		Galvanic Furnace Gas			CO_2	146.60	124.29	2.3%	2.9%	4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Refinary Gas			CO_2	27,354.02	31,949.38	2.3%	5.0%	6%	0.1%	0.2%	2.7%	0.0%	0.1%	0.1%
		LPG			CO_2	37,373.48	32,046.84	2.3%	0.1%	2%	0.1%	-0.7%	2.7%	0.0%	0.1%	0.1%
	Gaseous Fuels	LNG			CO_2	76,303.80	165,148.09	0.3%	0.1%	0%	0.0%	7.0%	14.1%	0.0%	0.1%	0.1%
		Indigenous Natural Gas			CO_2	2,225.86	2,566.08	0.3%	0.6%	1%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
		Town Gas*			CO_2	34,211.10	87,893.27	0.3%	0.5%	1%	0.0%	4.3%	7.5%	0.0%	0.0%	0.0%
		Small Scale Town Gas*			CO_2	1,130.79	1,080.14	0.3%	0.1%	0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
	Other Fuels	Municipal Solid Waste (Plastics)			CO_2	5,856.61	4,711.25	16.0%	4.3%	17%	0.1%	-0.1%	0.4%	0.0%	0.1%	0.1%
		Municipal Solid Waste (Waste textile)			CO_2	584.61	1,229.90	22.4%	4.3%	23%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
		Industrial Solid Waste (Waste Oil)			CO_2	20.63	79.04	104.4%	4.8%	105%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Industrial Solid Waste (Plastics)			CO_2	30.87	374.59	100.0%	4.8%	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Raw material and fuel use of MSW			CO_2	0.00	460.64	16.0%	4.3%	17%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Raw material and fuel use of ISW (Waste Oil)			CO_2	2,018.99	3,215.93	104.4%	4.8%	105%	0.3%	0.1%	0.3%	0.0%	0.4%	0.4%
		Raw material and fuel use of ISW (Waste Plastics)			CO_2	54.32	1,519.61	12.3%	4.8%	13%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
		Raw material and fuel use of Waste tire			CO_2	524.23	945.90	14.5%	4.8%	15%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
		Fuel use of RDF and RPF			CO_2	25.63	1,475.38	10.6%	42.6%	44%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
1A. Fuel Combustion (Stationary: CH4, N2O)	Solid Fuels, Liquid Fuels, Gaseous Fuels and biomass				CH_4	543.30	683.77	– 1)	– 1)	47%	0.0%	0.0%	0.1%	NA	NA	NA
					N_2O	2,164.43	4,063.50	– 1)	– 1)	33%	0.1%	0.1%	0.3%	NA	NA	NA
	Other Fuels (part of 6C. Waste incineration)	Municipal Solid Waste (Plastics)			CH_4	11.33	2.46	–	–	101%	0.0%	0.0%	0.0%	NA	NA	NA
		Municipal Solid Waste (Waste textile)			N_2O	369.25	290.93	–	–	42%	0.0%	0.0%	0.0%	NA	NA	NA
		Industrial Solid Waste (Waste Oil)			CH_4	0.02	0.23	100.0%	111.5%	150%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Industrial Solid Waste (Plastics)			N_2O	3.30	2.94	100.0%	58.8%	116%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Raw material and fuel use of MSW			CH_4	0.00	0.00	10.0%	179.4%	180%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.00	0.00	10.0%	111.2%	112%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Raw material and fuel use of ISW	Waste Oil		CH_4	0.25	0.53	–	–	74%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	4.90	13.08	–	–	41%	0.0%	0.0%	0.0%	NA	NA	NA
			Waste Plastics		CH_4	0.01	3.48	10.0%	91.7%	92%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.05	4.55	10.0%	29.7%	31%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Waste Wood		CH_4	36.94	74.36	100.0%	80.2%	128%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	6.18	12.43	100.0%	45.3%	110%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Raw material and fuel use of Waste tire			CH_4	0.65	0.65	–	–	91%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	1.55	4.92	–	–	26%	0.0%	0.0%	0.0%	NA	NA	NA
		Fuel use of RDF and RPF			CH_4	0.00	0.20	–	–	49%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	0.16	8.47	–	–	33%	0.0%	0.0%	0.0%	NA	NA	NA
1A.Fuel Combustion (Transport: CH4, N2O)	a. Civil Aviation				CH_4	2.94	4.98	10.0%	200.0%	200%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	69.75	96.34	10.0%	10000.0%	10000%	0.8%	0.0%	0.0%	0.2%	0.0%	0.2%
	b. Road Transportation				CH_4	263.88	127.74	50.0%	–	64%	0.0%	0.0%	0.0%	NA	0.0%	NA
					N_2O	3,914.04	2,035.51	50.0%	–	71%	0.1%	-0.2%	0.2%	NA	0.1%	NA
	c. Railways				CH_4	1.10	0.64	–	–	10%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	121.22	70.38	–	–	11%	0.0%	0.0%	0.0%	NA	NA	NA
	d. Navigation				CH_4	26.76	21.30	13.0%	200.0%	200%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	112.87	89.82	13.0%	1000.0%	1000%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
1B. Fugitive Emissions from Fuels	1. Solid Fuels	a. Coal Mining	i. Underground Mines	Mining Activities	CH_4	2,980.80	16.49	–	–	5%	0.0%	-0.3%	0.0%	NA	NA	NA
				Post-Mining Activities	CH_4	233.53	18.21	10.0%	200.0%	200%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			ii. Surface Mines	Mining Activities	CH_4	19.50	11.63	10.0%	200.0%	200%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				Post-Mining Activities	CH_4	1.70	1.01	10.0%	200.0%	200%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	2. Oil and Natural Gas	a. Oil		i. Exploration	CO_2	0.03	0.01	10.0%	25.0%	27%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	0.03	0.01	10.0%	25.0%	27%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.00	0.00	10.0%	25.0%	27%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				ii. Production	CO_2	0.11	0.08	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	12.80	8.56	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				iii. Transport	CO_2	0.00	0.00	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	0.76	1.25	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				iv. Refining / Storage	CH_4	14.73	13.53	0.9%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		b. Natural Gas		ii. Production / Processing	CO_2	0.25	0.39	–	25.0%	25%	0.0%	0.0%	0.0%	0.0%	NA	NA
					CH_4	159.12	243.59	–	25.0%	25%	0.0%	0.0%	0.0%	0.0%	NA	NA
				iii. Transmission	CH_4	15.12	23.17	10.0%	25.0%	27%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				iv. Distribution	CH_4	13.69	16.73	–	25.0%	21%	0.0%	0.0%	0.0%	0.0%	NA	NA
		c. Venting and Flaring	Venting	i. oil	CO_2	0.01	0.00	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	12.19	8.15	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Flaring	i. oil	CO_2	28.17	18.84	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	1.22	0.81	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.08	0.06	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				ii. Gas	CO_2	8.06	12.39	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					CH_4	1.04	1.60	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.03	0.05	5.0%	25.0%	25%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A7-17 Results of the uncertainty assessment (continued)

A					B	C	D	E	F	G	H	I	J	K	L	M
IPCC source category					Gas	Base year emissions / removals	2012 emissions / removals	Activity data uncertainty	EF or RF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2012	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF or RF 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	See footnote 1.	D/ΣC	I*F	J*E*√2	(K^2+L^2)^1/2
						Gg-CO_2 eq.	Gg-CO_2 eq.	%	%	%	%	%	%	%	%	%
Total						1,167,502.21	1,268,052.37				2%					1%
2. Industrial Processes	A. Mineral Products	1. Cement Production			CO_2	37,904.87	25,059.57	10.0%	3.0%	10%	0.2%	-1.4%	2.1%	0.0%	0.3%	0.3%
		2. Lime Production			CO_2	6,674.45	5,670.13	5.0%	15.0%	16%	0.1%	-0.1%	0.5%	0.0%	0.0%	0.0%
		3. Limestone & Dolomite Use	Limestone		CO_2	8,996.43	6,391.55	4.8%	16.4%	17%	0.1%	-0.3%	0.5%	0.0%	0.0%	0.1%
			Dolomite		CO_2	1,467.50	1,642.47	3.9%	3.5%	5%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
		4. Soda Ash Production and Use			CO_2	267.28	142.26	6.3%	15.0%	16%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	B. Chemical Industries	1. Ammonia Production			CO_2	3,384.68	1,837.56	5.0%	22.5%	23%	0.0%	-0.2%	0.2%	0.0%	0.0%	0.0%
		Chemical Industries other than Anmonia Production			CO_2	824.39	578.12	5.0%	77.2%	77%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		2. Nitric Acid,			N_2O	765.70	474.57	5.0%	46.0%	46%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		3. Adipic Acid			N_2O	7,501.25	156.76	2.0%	9.0%	9%	0.0%	-0.7%	0.0%	-0.1%	0.0%	0.1%
		whole of Chemical Industires			CH_4	338.05	104.33	5.0%	98.5%	99%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	C. Metal Production	1. Iron and steel			CO_2	356.09	174.20	–	–	5%	0.0%	0.0%	0.0%	NA	NA	NA
					CH_4	15.47	12.49	5.0%	163.0%	163%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		2. Ferroalloy			CH_4	3.89	2.70	5.0%	163.0%	163%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2. Industrial Processes (F-gas)	C. Metal Production	3. Aluminium			PFCs	137.15	9.02	5.0%	33.0%	33%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		4. SF6 Used in Aluminium and Magnesium Foundries			SF_6	153.61	191.20	5.0%	–	5%	0.0%	0.0%	0.0%	NA	0.0%	NA
					HFCs	NO	1.17	5.0%	–	5%	0.0%	NA	0.0%	NA	0.0%	NA
	E. Production of F-gas	1. By-product Emissions (HCFC-22)			HFCs	12,592.30	14.04	5.0%	2.0%	5%	0.0%	-1.2%	0.0%	0.0%	0.0%	0.0%
		2. Fugitive Emissions			HFCs	1.30	78.38	10.0%	100.0%	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					PFCs	276.08	122.16	10.0%	100.0%	100%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					SF_6	3,638.23	129.06	10.0%	100.0%	100%	0.0%	-0.3%	0.0%	-0.3%	0.0%	0.3%
	F. Consumption of F-gas	1. Refrigeration and Air Conditioning Equipment	Domestic Refrigerator	manufacturing	HFCs	NO	330.49	40.0%	50.0%	64%	0.0%	NA	0.0%	NA	0.0%	NA
				stock	HFCs	NO	IE	40.0%	50.0%	64%	NA	NA	NA	NA	NA	NA
				disposal	HFCs	NO	IE	40.0%	–	40%	NA	NA	NA	NA	NA	NA
			Commercial Refrigerator	manufacturing	HFCs	NO	15,010.42	40.0%	50.0%	64%	0.8%	NA	1.3%	NA	0.7%	NA
				stock	HFCs	NO	IE	40.0%	50.0%	64%	NA	NA	NA	NA	NA	NA
				disposal	HFCs	NO	IE	40.0%	–	40%	NA	NA	NA	NA	NA	NA
			Stationary Air-Conditioning	manufacturing	HFCs	NO	4,138.48	40.0%	50.0%	64%	0.2%	NA	0.4%	NA	0.2%	NA
				stock	HFCs	NO	IE	40.0%	50.0%	64%	NA	NA	NA	NA	NA	NA
				disposal	HFCs	NO	IE	40.0%	–	40%	NA	NA	NA	NA	NA	NA
			Mobile Air-Conditioning	manufacturing	HFCs	NO	2,440.96	40.0%	50.0%	64%	0.1%	NA	0.2%	NA	0.1%	NA
				stock	HFCs	NO	IE	40.0%	50.0%	64%	NA	NA	NA	NA	NA	NA
				disposal	HFCs	NO	IE	40.0%	–	40%	NA	NA	NA	NA	NA	NA
		2. Foam Blowing		manufacturing	HFCs	1.22	134.42	50.0%	50.0%	71%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
				stock	HFCs	NO	160.05	50.0%	50.0%	71%	0.0%	NA	0.0%	NA	0.0%	NA
		3. Fire Extinguisher		manufacturing	HFCs	NO	7.01	40.0%	50.0%	64%	0.0%	NA	0.0%	NA	0.0%	NA
		4. Aerosols / MDI	Aerosols	manufacturing	HFCs	NO	75.75	40.0%	–	40%	0.0%	NA	0.0%	NA	0.0%	NA
				stock	HFCs	NO	305.59	40.0%	–	40%	0.0%	NA	0.0%	NA	0.0%	NA
			MDI	manufacturing	HFCs	NO	4.55	40.0%	–	40%	0.0%	NA	0.0%	NA	0.0%	NA
				stock	HFCs	NO	148.58	40.0%	–	40%	0.0%	NA	0.0%	NA	0.0%	NA
		5. Solvents			PFCs	3,725.57	1,266.47	40.0%	–	40%	0.0%	-0.2%	0.1%	NA	0.1%	NA
		7. Semiconductor Manufacture			HFCs	0.43	75.81	40.0%	50.0%	64%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					PFCs	1,137.91	1,360.63	40.0%	50.0%	64%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%
					SF_6	872.15	511.25	40.0%	50.0%	64%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		8. Electrical Equipment		manufacturing	SF_6	7,387.27	152.96	40.0%	30.0%	50%	0.0%	-0.7%	0.0%	-0.2%	0.0%	0.2%
				stock	SF_6	1,116.59	600.62	40.0%	50.0%	64%	0.0%	-0.1%	0.1%	0.0%	0.0%	0.0%
		9.Other - Railway Silicon Rectifiers			PFCs	NE,NO	0.00	40.0%	–	40%	0.0%	NA	0.0%	NA	0.0%	NA
3. SOPU	D. Other	Anaesthesia			N_2O	287.07	90.68	5.0%	–	5%	0.0%	0.0%	0.0%	NA	0.0%	NA
4. Agriculture	A. Enteric Fermentation	Dairy Cattle			CH_4	3,917.83	3,007.72	5.0%	–	15%	0.0%	-0.1%	0.3%	NA	0.0%	NA
		Non-Dairy Cattle			CH_4	3,322.55	3,114.45	5.0%	–	19%	0.0%	0.0%	0.3%	NA	0.0%	NA
		Buffalo			CH_4	0.25	0.10	100.0%	50.0%	112%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Sheep			CH_4	1.88	1.23	100.0%	50.0%	112%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Goat			CH_4	2.22	1.19	100.0%	50.0%	112%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Swine			CH_4	261.75	223.29	0.9%	50.0%	50%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Horse			CH_4	43.37	30.76	100.0%	50.0%	112%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	B. Manure Management	Dairy Cattle			CH_4	2,437.88	1,796.31	–	–	78%	0.1%	-0.1%	0.2%	NA	NA	NA
					N_2O	856.35	925.52	–	–	91%	0.1%	0.0%	0.1%	NA	NA	NA
		Non-Dairy Cattle			CH_4	93.86	115.81	–	–	73%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	876.23	964.00	–	–	125%	0.1%	0.0%	0.1%	NA	NA	NA
		Buffalo			CH_4	0.01	0.00	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.01	0.00	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Swine			CH_4	362.41	142.31	0.9%	–	106%	0.0%	0.0%	0.0%	NA	0.0%	NA
					N_2O	1,005.60	1,283.39	0.9%	–	92%	0.1%	0.0%	0.1%	NA	0.0%	NA
		Poultry (Hen, Broiler)			CH_4	49.32	63.24	12.4%	–	54%	0.0%	0.0%	0.0%	NA	0.0%	NA
					N_2O	432.38	538.48	12.4%	–	80%	0.0%	0.0%	0.0%	NA	0.0%	NA
		Sheep			CH_4	0.13	0.08	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.11	0.07	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Goat			CH_4	0.10	0.05	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.12	0.07	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Horse			CH_4	5.01	3.55	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.56	0.40	100.0%	100.0%	141%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	C. Rice Cultivation	Continuously Flooded			CH_4	242.62	191.05	0.3%	116.3%	116%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Intermittently Flooded	Straw amendment		CH_4	4,578.50	3,762.99	0.3%	–	32%	0.1%	-0.1%	0.3%	NA	0.0%	NA
			Various compost amendment		CH_4	1,188.09	1,038.14	0.3%	–	32%	0.0%	0.0%	0.1%	NA	0.0%	NA
			No-amendment		CH_4	950.47	488.21	0.3%	–	46%	0.0%	0.0%	0.0%	NA	0.0%	NA
	D. Agricultural Soils	1. Direct Soil Emissions	Synthetic Fertilizers		N_2O	1,908.13	1,247.41	–	–	139%	0.1%	-0.1%	0.1%	NA	NA	NA
			Animal Waste Applied to Soils		N_2O	1,832.20	1,407.41	–	–	152%	0.2%	0.0%	0.1%	NA	NA	NA
			N-Fixing Crops		N_2O	97.18	77.27	–	–	99%	0.0%	0.0%	0.0%	NA	NA	NA
			Crop residues		N_2O	586.37	479.10	–	–	211%	0.1%	0.0%	0.0%	NA	NA	NA
			Organic soil		N_2O	120.40	115.79	–	–	712%	0.1%	0.0%	0.0%	NA	NA	NA
		2. Pasture, Range and Paddock Manure			N_2O	67.91	50.26	–	–	133%	0.0%	0.0%	0.0%	NA	NA	NA
		3. Indirect Emissions	Atmospheric Deposition		N_2O	1,590.62	1,221.60	–	–	75%	0.1%	0.0%	0.1%	NA	NA	NA
			N Leaching & Run-off		N_2O	2,174.38	1,541.05	–	–	97%	0.1%	-0.1%	0.1%	NA	NA	NA
	F. Field Burning of Agricultural Residue	1. Cereals	Wheat		CH_4	8.74	5.43	–	–	186%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	1.91	1.19	–	–	185%	0.0%	0.0%	0.0%	NA	NA	NA
			Barley		CH_4	3.05	1.11	–	–	185%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	0.71	0.26	–	–	187%	0.0%	0.0%	0.0%	NA	NA	NA
			Maize		CH_4	39.63	29.24	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	8.39	6.19	50.0%	423.0%	426%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Oats		CH_4	0.35	0.49	–	–	156%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	0.24	0.41	–	–	170%	0.0%	0.0%	0.0%	NA	NA	NA
			Rye		CH_4	0.03	0.02	–	–	130%	0.0%	0.0%	0.0%	NA	NA	NA
					N_2O	0.02	0.01	–	–	154%	0.0%	0.0%	0.0%	NA	NA	NA
			Rice		CH_4	43.28	16.25	50.0%	178.0%	185%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	12.10	4.62	50.0%	175.0%	182%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		2. Pulse	Peas		CH_4	0.17	0.08	20.0%	481.0%	481%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.11	0.05	20.0%	423.0%	423%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Soybeans		CH_4	1.62	1.53	50.0%	176.0%	183%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	1.07	1.01	50.0%	182.0%	189%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Other (Adzuki beans)		CH_4	0.47	0.30	50.0%	179.0%	186%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.28	0.18	50.0%	180.0%	187%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Other (kidney beans)		CH_4	0.11	0.04	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.07	0.03	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Other (peanuts)		CH_4	0.16	0.08	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.06	0.03	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		3. Tuber & Roots	Potatoes		CH_4	0.61	0.42	20.0%	418.0%	418%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.78	0.54	20.0%	419.0%	419%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			Other: Sugarbeet		CH_4	1.24	1.13	50.0%	417.0%	420%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	1.14	1.04	50.0%	419.0%	422%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		4. Sugar Cane			CH_4	1.19	0.58	50.0%	418.0%	421%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
					N_2O	0.38	0.18	50.0%	423.0%	426%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table A7-18 Results of the uncertainty assessment (continued)

A			B	C	D	E	F	G	H	I	J	K	L	M
IPCC source category			Gas	Base year emissions / removals	2012 emissions / removals	Activity data uncertainty	EF or RF uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in 2012	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by EF or RF 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	See footnote 1.	D/ΣC	I*F	J*E*√2	(K^2+L^2)^1/2
				Gg-CO_2 eq.	Gg-CO_2 eq.	%	%	%	%	%	%	%	%	%
Total				1,167,502.21	1,268,052.37				2%					1%
5. LULUCF	A. Forest Land	1. Forest Land remaining Forest Land	CO_2	-76,556.18	-77,324.15	–	–	11%	-0.7%	0.5%	-6.6%	NA	NA	NA
		2. Land converted to Forest Land	CO_2	-2,006.49	-348.59	–	–	38%	0.0%	0.2%	0.0%	NA	NA	NA
			CH_4	8.51	1.59	37.0%	25.0%	45%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			N_2O	1.73	0.71	37.0%	28.6%	108%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	B. Cropland	1. Cropland remaining Cropland	CO_2	1,602.96	1,461.22	–	–	19%	0.0%	0.0%	0.1%	NA	NA	NA
		2. Land converted to Cropland	CO_2	2,585.24	179.99	–	–	25%	0.0%	-0.2%	0.0%	NA	NA	NA
			CH_4	NE,NO	NE,NO	–	–	–	NA	NA	NA	NA	NA	NA
			N_2O	70.28	3.98	–	–	82%	0.0%	0.0%	0.0%	NA	NA	NA
	C. Grassland	1. Grassland remaining Grassland	CO_2	NO,NE,NA	NA,NO,NE	–	–	–	NA	NA	NA	NA	NA	NA
		2. Land converted to Grassland	CO_2	-230.99	-116.01	–	–	97%	0.0%	0.0%	0.0%	NA	NA	NA
			CH_4	NE,NO	NE,NO	–	–	–	NA	NA	NA	NA	NA	NA
			N_2O	NE,NO	NE,NO	–	–	–	NA	NA	NA	NA	NA	NA
	D. Wetlands	1. Wetlands remaining Wetlands	CO_2	NO,NE	NO,NE	–	–	–	NA	NA	NA	NA	NA	NA
		2. Land converted to Wetlands	CO_2	90.94	31.83	–	–	29%	0.0%	0.0%	0.0%	NA	NA	NA
			CH_4	NE,NO	NE,NO	–	–	–	NA	NA	NA	NA	NA	NA
			N_2O	NE,NO	NE,NO	–	–	–	NA	NA	NA	NA	NA	NA
	E. Settlements	1. Settlements remaining Settlements	CO_2	-960.76	-968.62	–	–	35%	0.0%	0.0%	-0.1%	NA	NA	NA
		2. Land converted to Settlements	CO_2	6,076.47	1,476.95	–	–	31%	0.0%	-0.4%	0.1%	NA	NA	NA
			CH_4	NO	NO	–	–	–	NA	NA	NA	NA	NA	NA
			N_2O	NO	NO	–	–	–	NA	NA	NA	NA	NA	NA
	F. Other Land	1. Other Land remaining Other Land	CO_2	–	–	–	–	–	NA	NA	NA	NA	NA	NA
		2. Land converted to Other Land	CO_2	1,950.14	288.96	–	–	40%	0.0%	-0.2%	0.0%	NA	NA	NA
			CH_4	NO	NO	–	–	–	NA	NA	NA	NA	NA	NA
			N_2O	NO	NO	–	–	–	NA	NA	NA	NA	NA	NA
	G. Other	CO_2 emissions from agricultural lime application	CO_2	550.24	246.78	–	–	51%	0.0%	0.0%	0.0%	NA	NA	NA
6. Waste	A. Solid Waste Disposal on Land	1. Managed Landfill Sites: Food Waste	CH_4	1,319.91	257.96	32.4%	42.4%	53%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
		Paper	CH_4	3,096.96	1,303.30	42.7%	42.4%	60%	0.1%	-0.2%	0.1%	-0.1%	0.1%	0.1%
		Textile	CH_4	202.64	90.19	42.9%	43.8%	61%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Wood	CH_4	973.45	904.18	56.6%	42.5%	71%	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%
		Digested Sewage Sludge	CH_4	115.01	19.42	32.0%	44.2%	55%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Other Sewage Sludge	CH_4	573.33	99.79	32.0%	44.2%	55%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Human Waste Sludge	CH_4	260.92	51.00	32.6%	44.2%	55%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Waterworks Sludge	CH_4	70.40	23.47	31.7%	108.6%	113%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Organic Sludge from Manufacture	CH_4	1,004.59	127.87	33.4%	54.0%	63%	0.0%	-0.1%	0.0%	0.0%	0.0%	0.0%
		Livestock Waste	CH_4	28.75	20.85	49.4%	46.9%	68%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		3. Other: Inappropriate Disposal	CH_4	7.29	42.34	66.8%	42.5%	79%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	B. Wastewater Handling	1. Industrial Wastewater	CH_4	135.76	102.72	37.4%	60.0%	71%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			N_2O	127.81	120.77	51.1%	300.0%	304%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		2. Domestic and Commercial Wastewater: Sewage Treatment Plants	CH_4	181.48	254.31	10.4%	30.9%	33%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			N_2O	432.26	481.30	10.4%	145.7%	146%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
		Domestic wastewater treatment Facilities	CH_4	710.28	690.44	10.0%	86.8%	87%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
			N_2O	488.51	528.47	10.0%	71.0%	72%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Human-Waste Treatment Facilities	CH_4	110.14	10.39	12.3%	100.0%	101%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			N_2O	69.56	5.11	33.9%	100.0%	106%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
		Degradation of Domestic Wastewater in Nature	CH_4	1,264.60	405.97	–	–	76%	0.0%	-0.1%	0.0%	NA	NA	NA
			N_2O	137.38	39.24	–	–	76%	0.0%	0.0%	0.0%	NA	NA	NA
	C. Waste Incineration	Municipal Solid Waste: Plastics	CO_2	5,040.90	2,517.43	16.0%	4.3%	17%	0.0%	-0.3%	0.2%	0.0%	0.0%	0.0%
		Waste textile	CO_2	503.19	657.19	22.4%	4.3%	23%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
			CH_4	9.75	1.32	–	–	101%	0.0%	0.0%	0.0%	NA	NA	NA
			N_2O	317.82	155.46	–	–	42%	0.0%	0.0%	0.0%	NA	NA	NA
		Industrial Solid Waste: Waste Mineral Oil	CO_2	3,651.84	3,662.67	104.4%	4.8%	105%	0.3%	0.0%	0.3%	0.0%	0.5%	0.5%
		Plastics	CO_2	2,120.24	3,497.28	100.0%	4.8%	100%	0.3%	0.1%	0.3%	0.0%	0.4%	0.4%
			CH_4	3.60	6.14	100.0%	111.5%	150%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
			N_2O	1,169.27	1,458.51	100.0%	58.8%	116%	0.1%	0.0%	0.1%	0.0%	0.2%	0.2%
		Specially Contorolled Industrial Solid Waste	CO_2	946.78	1,665.35	–	–	167%	0.2%	0.1%	0.1%	NA	NA	NA
			CH_4	0.12	0.97	–	–	142%	0.0%	0.0%	0.0%	NA	NA	NA
			N_2O	5.95	13.83	–	–	159%	0.0%	0.0%	0.0%	NA	NA	NA
	D. Oher	Decomposition of petroleum-derived surface-active agent	CO_2	702.83	515.07	–	–	25%	0.0%	0.0%	0.0%	NA	NA	NA
		Composting of Organic Waste	CH_4	92.01	164.83	–	–	74%	0.0%	0.0%	0.0%	NA	NA	NA
			N_2O	81.50	146.00	–	–	86%	0.0%	0.0%	0.0%	NA	NA	NA

1) 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 from row x of the table from the corresponding column, representing a specific category

$\sum C_i, \sum D_i$ = sum over all categories (rows) of the inventory of the corresponding column

Annex 8. 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 A 8-1 Explanation of each MS Excel file

category	file name	contents
	JPN-2014-1990-v1.1.xlsx ～ JPN-2014-2012-v1.1.xlsx, KP-JPN-2014-1990-v1.1.xlsx, KP-JPN-2014-2008-v1.1.xlsx ～ KP-JPN-2014-2012-v1.1.xlsx	Common reporting format provided by UNFCCC secretariat
1. Energy	1A-L3-nonCO2-1990-2014.xlsx ～ 1A-L3-nonCO2-2012-2014.xlsx	Non-CO_2 emissions from stationary facilities
	1A-L3-CO2-1990-2014.xlsx ～ 1A-L3-CO2-2012-2014.xlsx	CO_2 emissions from fuel combustions
	1A-L3-NOxSO2-2014.xlsx	Emissions of Non-CO_2 from stationary combustion
	1A-L3-CRF-2014.xlsx	CRF format data of GHG emissions from fuel combution (including emissions by energy use of waste)
	1A-L3-timeseries-2014.xlsx	Time-series data of GHG emissions from fuel combution
	1A-L2-MAP-IEF-1990-2014.xlsx ～ 1A-L2-MAP_IEF-2008-2014.xlsx	Implied Emission Factors of Non-CO2 from stationary combustion
	1A-L2-nonCO2-ADEF-2014.xlsx	Activity Data and Emission Factors of Non-CO_2 from fuel combustion
	1A-L2-nonCO2-EF-2014.xlsx	Emission Factors of Non-CO_2 from fuel combustion
	1A-L2-EBEF-2014.xlsx	Emission Factors for CO_2 from fuel combustion
	1A-L1-EB-2014.xlsx	Data of the General Energy Statistics using in Mobile (CH_4, N_2O), Fugitive emissions from fuels and IP sector
	1A3-L3-CH4N2O-2014.xlsx	GHG emissions from Mobile Combustion (transport sector) (except CO_2)
	1A3-L2-ADEF-2014.xlsx	Activity Data and Emission Factors for Mobile Combustion (transport sector)
	1B-L3-2014.xlsx	Fugitive GHG emissions from fuels
	1B-L2-ADEF-2014.xlsx	Activity Data and Emission Factors for Fugitive Emissions from Fuels
2. Industrial Processes	2-L2-ADEF-2014.xlsx	Activity Data and Emission Factors of Caotegory2 (except F-gas)
	2-L3-2014.xlsx	GHG emissions from Category2 (Industrial Processes)
	2-L3-Fgas-2014.xlsx	F-gas (HFCs, PFCs, SF_6) emissions
3. Solvent and Other Product Use	3-L3-2014.xlsx	N2O emissions from anesthesia
4. Agriculture	4A-L3-CH4-2014.xlsx	CH_4 emissions from enteric fermentation
	4B-L3-CH4N2O-2014.xlsx	GHG emissions from manure management
	4C-L3-CH4-2014.xlsx	CH_4 emissions from rice cultivation
	4D-L3-N2O-2014.xlsx	N_2O emissions from agricultural soils
	4F-CH4N2OCO-2014.xlsx	GHG emissions from field burning of agricultural residues
	4-L2-ADEF-2014.xlsx	Activity Data and Emission Factors of Caotegory4
5. LULUCF	5-L3-nonCSC-2014.xlsx	GHG emissions excluindg carbon stock change
	5A-L3-CO2-2014.xlsx	CO_2 emissions and removals from forest land
	5B-L3-CO2-2014.xlsx	CO_2 emissions and removals from cropland
	5C-L3-CO2-2014.xlsx	CO_2 emissions and removals from grassland
	5D-L3-CO2-2014.xlsx	CO_2 emissions and removals from wetlands
	5E-L3-CO2-2014.xlsx	CO_2 emissions and removals from settlements
	5F-L3-CO2-2014.xlsx	CO_2 emissions and removals from other land
	5-L2-LandArea-2014.xlsx	Land area for each land use category
	5-L2-Parameter-2014.xlsx	Parameters for each land use category
	5-L2-Soil-C&G-2014.xlsx	Carbon stock changes in cropland and grassland
6. Waste	6A3-L2-AD-2014.xlsx	Activity data of solid waste disposal on land (other)
	6A-L3-2014.xlsx	GHGs emissions from solid waste disposal on land
	6A-L2-AD-2014.xlsx	Activity data of solid waste disposal on land
	6B-L3-2014.xlsx	GHGs emissions from wastewater handling
	6B-L2-AD-2014.xlsx	Activity data of wastewater handling
	6B-L2-EF-2014.xlsx	Emission Factor of wastewater handling
	6C-L3-nonCO2-2014.xlsx	GHGs emissions from waste incineration (exclude CO_2)
	6C-L2-AD-2014.xlsx	Activity data of waste incineration
	6C-L3-CO2-2014.xlsx	CO_2 emissions from waste incineration
	6C-L3-Energy-2014.xlsx	GHGs (CO_2, CH_4, N_2O, CO, NOx, SOx, NMVOC) Emissions from the incineration of waste for energy and use as alternative fuels
	6D-L3-2014.xlsx	GHGs emissions from other waste
	6D-L2-2014.xlsx	Activity data of other waste
	6-L2-EF-2014	Emission factors of Category6 (Waste)
7. Other	7-L3-2014.xlsx	CO Emissions from tobaccos
Memo Item	1C-L3-bunker-2014.xlsx	GHGs emissions from bunker fuels
KP-LULUCF	KP-3-RV-CRFreporter-2014.xlsx	GHG emissions and removals from Revetation
	KP-3-Summary-2014.xlsx	GHG emissions and removals from KP3.3 and 3.4 activities
	KP-2-AR-2014.xlsx	GHG emissions and removals from Afforestation/Reforestation
	KP-2-D-2014.xlsx	GHG emissions and removals from Deforestation
	KP-2-FM-2014.xlsx	GHG emissions and removals from Forest Management
	KP-2-RV-2014.xlsx	GHG emissions and removals from Revegetation

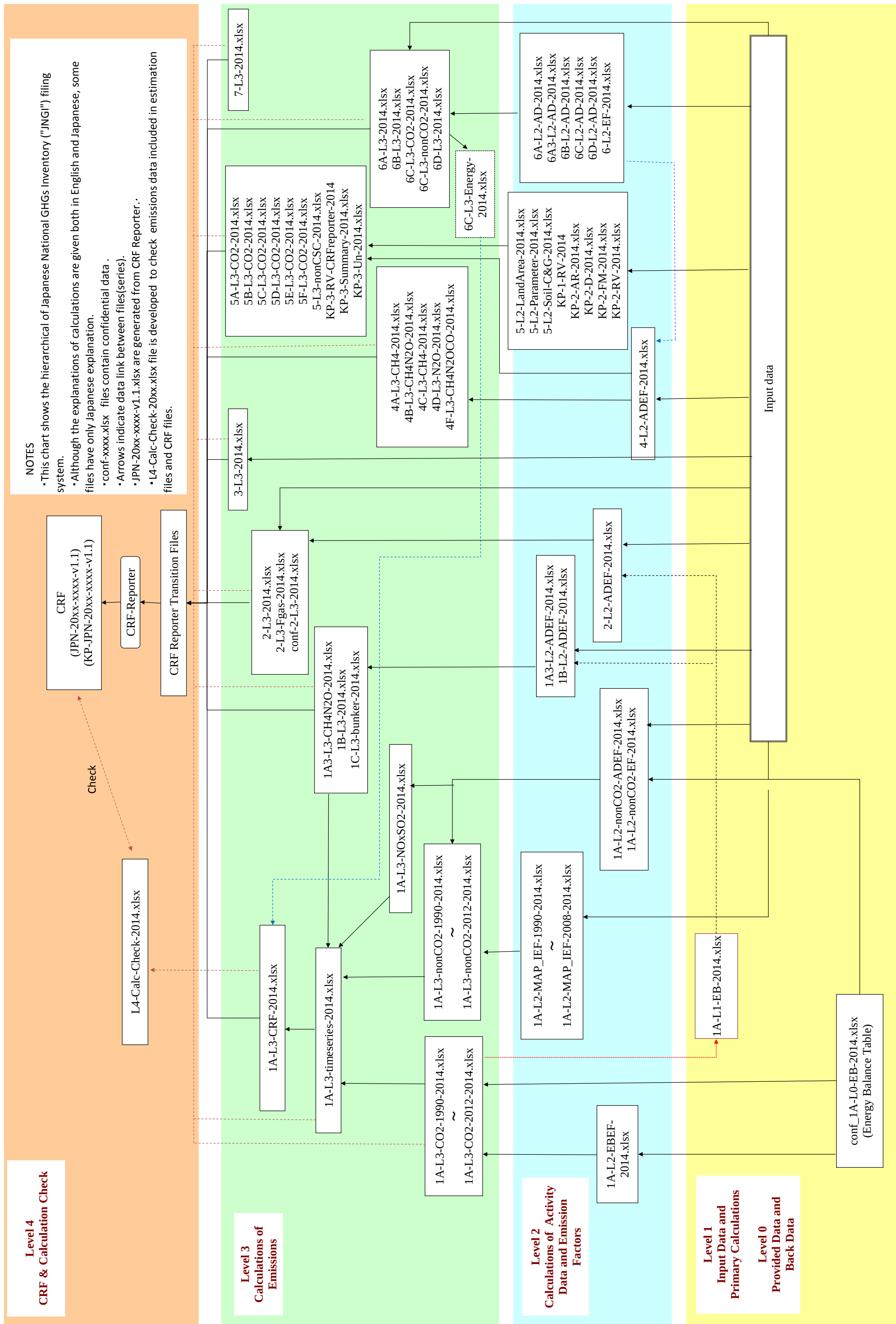

Figure A 8-1 Hierarchical structure of Japan's National GHG Inventory File System

Annex 9. Summary of Common Reporting Format

"Summary.2 Table" of the CRF indicated below shows emissions and removals for every year.

Table A9-1 Emissions and Removals in 1990

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,074,239.30**	**32,423.38**	**29,799.72**	**12,595.25**	**5,276.71**	**13,167.85**	**1,167,502.21**
1. Energy	**1,068,296.26**	**4,353.42**	**6,767.83**				**1,079,417.50**
A. Fuel Combustion (Sectoral Approach)	1,068,259.64	887.18	6,767.71				1,075,914.53
1. Energy Industries	324,253.21	29.73	922.26				325,205.20
2. Manufacturing Industries and Construction	371,311.49	355.35	1,354.08				373,020.93
3. Transport	211,056.81	294.68	4,217.89				215,569.37
4. Other Sectors	161,638.12	207.42	273.49				162,119.03
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	36.62	3,466.24	0.11				3,502.98
1. Solid Fuels	NE,NO	3,235.53	NE,NO				3,235.53
2. Oil and Natural Gas	36.62	230.71	0.11				267.45
2. Industrial Processes	**59,875.69**	**357.41**	**8,266.95**	**12,595.25**	**5,276.71**	**13,167.85**	**99,539.86**
A. Mineral Products	55,310.54	NA,NO	NA,NO				55,310.54
B. Chemical Industry	4,209.07	338.05	8,266.95	NA	NA	NA	12,814.07
C. Metal Production	356.09	19.36	NO	IE,NE,NO	137.15	153.61	666.21
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				12,593.60	276.08	3,638.23	16,507.91
F. Consumption of Halocarbons and SF_6 (2)				1.65	4,863.48	9,376.00	14,241.13
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**287.07**				**287.07**
4. Agriculture		**17,558.92**	**11,575.80**				**29,134.72**
A. Enteric Fermentation		7,549.84					7,549.84
B. Manure Management		2,948.72	3,171.35				6,120.07
C. Rice Cultivation		6,959.68					6,959.68
D. Agricultural Soils(3)		NA	8,377.20				8,377.20
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		100.68	27.25				127.93
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-66,898.43**	**8.51**	**72.02**				**-66,817.90**
A. Forest Land	-78,562.67	8.51	1.73				-78,552.43
B. Cropland	4,188.21	NE,NO	70.28				4,258.49
C. Grassland	-230.99	NE,NO	NE,NO				-230.99
D. Wetlands	90.94	NE,NO	NE,NO				90.94
E. Settlements	5,115.71	NE,NO	NE,NO				5,115.71
F. Other Land	1,950.14	NO	NO				1,950.14
G. Other	550.24	NA,NE	NA,NE				550.24
6. Waste	**12,965.78**	**10,145.12**	**2,830.06**				**25,940.96**
A. Solid Waste Disposal on Land	NE,NO	7,637.37					7,637.37
B. Waste-water Handling		2,402.25	1,255.52				3,657.78
C. Waste Incineration	12,262.95	13.48	1,493.04				13,769.47
D. Other	702.83	92.01	81.50				876.34
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	30,829.18	43.15	279.35				31,151.68
Aviation	13,189.32	7.84	130.44				13,327.60
Marine	17,639.86	35.31	148.92				17,824.08
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,749.26**						**18,749.26**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,234,320.12
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,167,502.21

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-2 Emissions and Removals in 1991

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,075,803.89**	**32,026.37**	**29,339.48**	**13,715.57**	**6,066.17**	**14,677.86**	**1,171,629.35**
1. Energy	**1,076,104.87**	**3,980.03**	**7,044.77**				**1,087,129.67**
A. Fuel Combustion (Sectoral Approach)	1,076,051.20	893.28	7,044.61				1,083,989.08
1. Energy Industries	326,986.60	31.17	955.51				327,973.28
2. Manufacturing Industries and Construction	366,282.86	355.85	1,430.13				368,068.84
3. Transport	222,469.95	297.19	4,379.09				227,146.23
4. Other Sectors	160,311.79	209.06	279.88				160,800.73
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	53.67	3,086.75	0.16				3,140.59
1. Solid Fuels	NE,NO	2,830.32	NE,NO				2,830.32
2. Oil and Natural Gas	53.67	256.43	0.16				310.26
2. Industrial Processes	**60,982.03**	**347.06**	**7,539.75**	**13,715.57**	**6,066.17**	**14,677.86**	**103,328.44**
A. Mineral Products	56,474.62	NA,NO	NA,NO				56,474.62
B. Chemical Industry	4,184.37	328.72	7,539.75	NA	NA	NA	12,052.84
C. Metal Production	323.04	18.34	NO	IE,NE,NO	115.11	132.54	589.03
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				13,715.57	319.67	4,066.26	18,101.50
F. Consumption of Halocarbons and SF_6 (2)				18,070.00	5,631.39	10,479.06	34,180.46
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**356.85**				**356.85**
4. Agriculture		**17,681.22**	**11,435.42**				**29,116.65**
A. Enteric Fermentation		7,661.67					7,661.67
B. Manure Management		2,941.56	3,172.69				6,114.25
C. Rice Cultivation		6,977.75					6,977.75
D. Agricultural Soils (3)		NA	8,235.51				8,235.51
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		100.24	27.22				127.46
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry (1)	**-74,267.57**	**6.36**	**67.28**				**-74,193.94**
A. Forest Land	-85,920.88	6.36	1.46				-85,913.06
B. Cropland	3,209.26	NE,NO	65.81				3,275.08
C. Grassland	-341.21	NE,NO	NE,NO				-341.21
D. Wetlands	81.15	NE,NO	NE,NO				81.15
E. Settlements	6,046.60	NE,NO	NE,NO				6,046.60
F. Other Land	2,130.12	NO	NO				2,130.12
G. Other	527.37	NA,NE	NA,NE				527.37
6. Waste	**12,984.57**	**10,011.70**	**2,895.42**				**25,891.68**
A. Solid Waste Disposal on Land	NE,NO	7,565.70					7,565.70
B. Waste-water Handling		2,343.80	1,281.68				3,625.48
C. Waste Incineration	12,298.12	13.08	1,534.80				13,846.01
D. Other	686.45	89.12	78.93				854.49
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	32,531.98	45.53	294.78				32,872.29
Aviation	13,919.12	8.27	137.65				14,065.05
Marine	18,612.86	37.25	157.13				18,807.24
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,872.92**						**18,872.92**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,245,823.29
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,171,629.35

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-3 Emissions and Removals in 1992

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,084,493.26**	**31,681.13**	**29,543.59**	**14,058.48**	**6,163.47**	**16,188.59**	**1,182,128.52**
1. Energy	**1,083,526.98**	**3,624.86**	**7,239.15**				**1,094,390.99**
A. Fuel Combustion (Sectoral Approach)	1,083,470.03	911.72	7,238.97				1,091,620.72
1. Energy Industries	333,717.45	31.87	929.84				334,679.16
2. Manufacturing Industries and Construction	358,404.85	351.59	1,544.89				360,301.33
3. Transport	226,863.49	300.34	4,468.29				231,632.12
4. Other Sectors	164,484.24	227.91	295.95				165,008.10
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	56.95	2,713.14	0.17				2,770.26
1. Solid Fuels	NE,NO	2,453.32	NE,NO				2,453.32
2. Oil and Natural Gas	56.95	259.82	0.17				316.94
2. Industrial Processes	**60,993.20**	**321.49**	**7,452.41**	**14,058.48**	**6,163.47**	**16,188.59**	**105,177.65**
A. Mineral Products	56,567.06	NA,NO	NA,NO				56,567.06
B. Chemical Industry	4,101.09	303.73	7,452.41	NA	NA	NA	11,857.23
C. Metal Production	325.05	17.76	NO	IE,NE,NO	77.15	112.18	532.15
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				13,936.72	326.94	4,494.29	18,757.94
F. Consumption of Halocarbons and SF_6 (2)				121.77	5,759.38	11,582.12	17,463.27
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**413.01**				**413.01**
4. Agriculture		**17,772.44**	**11,351.65**				**29,124.10**
A. Enteric Fermentation		7,705.87					7,705.87
B. Manure Management		2,914.11	3,163.03				6,077.14
C. Rice Cultivation		7,059.04					7,059.04
D. Agricultural Soils(3)		NA	8,163.05				8,163.05
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		93.42	25.57				118.99
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-74,051.16**	**4.39**	**63.53**				**-73,983.23**
A. Forest Land	-86,284.84	4.39	1.26				-86,279.19
B. Cropland	3,296.04	NE,NO	62.27				3,358.31
C. Grassland	-295.25	NE,NO	NE,NO				-295.25
D. Wetlands	255.04	NE,NO	NE,NO				255.04
E. Settlements	6,728.23	NE,NO	NE,NO				6,728.23
F. Other Land	1,772.47	NO	NO				1,772.47
G. Other	477.14	NA,NE	NA,NE				477.14
6. Waste	**14,024.24**	**9,957.94**	**3,023.84**				**27,006.01**
A. Solid Waste Disposal on Land	NE,NO	7,529.58					7,529.58
B. Waste-water Handling		2,325.43	1,271.41				3,596.85
C. Waste Incineration	13,325.34	13.43	1,673.16				15,011.93
D. Other	698.90	89.49	79.26				867.65
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	32,937.28	45.92	298.63				33,281.83
Aviation	14,216.76	8.45	140.60				14,365.81
Marine	18,720.51	37.47	158.04				18,916.02
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,421.20**						**18,421.20**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,256,111.75
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,182,128.52

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-4 Emissions and Removals in 1993

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,073,690.55**	**31,117.51**	**29,374.06**	**14,428.86**	**8,862.41**	**16,194.22**	**1,173,667.61**
1. Energy	**1,077,164.28**	**3,128.15**	**7,304.49**				**1,087,596.92**
A. Fuel Combustion (Sectoral Approach)	1,077,111.06	927.37	7,304.33				1,085,342.77
1. Energy Industries	315,598.93	31.66	938.36				316,568.95
2. Manufacturing Industries and Construction	357,499.46	353.00	1,602.83				359,455.28
3. Transport	231,732.63	293.24	4,439.89				236,465.76
4. Other Sectors	172,280.05	249.47	323.25				172,852.78
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	53.21	2,200.78	0.16				2,254.16
1. Solid Fuels	NE,NO	1,937.32	NE,NO				1,937.32
2. Oil and Natural Gas	53.21	263.46	0.16				316.84
2. Industrial Processes	**59,938.82**	**319.79**	**7,302.85**	**14,428.86**	**8,862.41**	**16,194.22**	**107,046.94**
A. Mineral Products	55,713.23	NA,NO	NA,NO				55,713.23
B. Chemical Industry	3,894.83	303.08	7,302.85	NA	NA	NA	11,500.76
C. Metal Production	330.76	16.70	NO	IE,NE,NO	71.06	117.81	536.34
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				13,528.36	472.24	4,494.29	18,494.89
F. Consumption of Halocarbons and SF_6 [(2)]				900.49	8,319.11	11,582.12	20,801.72
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**411.66**				**411.66**
4. Agriculture		**17,860.81**	**11,242.79**				**29,103.60**
A. Enteric Fermentation		7,659.62					7,659.62
B. Manure Management		2,857.55	3,125.49				5,983.03
C. Rice Cultivation		7,247.60					7,247.60
D. Agricultural Soils[(3)]		NA	8,091.01				8,091.01
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		96.05	26.29				122.34
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[(1)]	**-77,186.59**	**24.22**	**61.47**				**-77,100.90**
A. Forest Land	-86,636.86	24.22	3.31				-86,609.33
B. Cropland	2,421.84	NE,NO	58.16				2,480.00
C. Grassland	-386.82	NE,NO	NE,NO				-386.82
D. Wetlands	141.62	NE,NO	NE,NO				141.62
E. Settlements	4,663.13	NE,NO	NE,NO				4,663.13
F. Other Land	2,128.91	NO	NO				2,128.91
G. Other	481.58	NA,NE	NA,NE				481.58
6. Waste	**13,774.05**	**9,784.53**	**3,050.80**				**26,609.38**
A. Solid Waste Disposal on Land	NE,NO	7,396.57					7,396.57
B. Waste-water Handling		2,284.56	1,296.88				3,581.44
C. Waste Incineration	13,093.30	13.36	1,674.17				14,780.83
D. Other	680.75	90.05	79.76				850.55
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	34,935.20	50.42	314.96				35,300.58
Aviation	13,856.19	8.23	137.03				14,001.45
Marine	21,079.01	42.19	177.93				21,299.12
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**17,570.58**						**17,570.58**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,250,768.52
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,173,667.61

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-5 Emissions and Removals in 1994

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,131,640.97**	**30,470.57**	**30,615.58**	**16,849.23**	**10,891.02**	**15,425.31**	**1,235,892.67**
1. Energy	**1,133,210.28**	**2,777.27**	**7,599.04**				**1,143,586.59**
A. Fuel Combustion (Sectoral Approach)	1,133,159.13	925.83	7,598.88				1,141,683.84
1. Energy Industries	356,359.51	33.81	1,010.42				357,403.74
2. Manufacturing Industries and Construction	365,878.17	361.95	1,743.27				367,983.39
3. Transport	243,687.04	295.04	4,519.39				248,501.48
4. Other Sectors	167,234.41	235.03	325.79				167,795.23
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	51.15	1,851.44	0.16				1,902.75
1. Solid Fuels	NE,NO	1,584.87	NE,NO				1,584.87
2. Oil and Natural Gas	51.15	266.57	0.16				317.88
2. Industrial Processes	**61,181.26**	**320.00**	**8,298.10**	**16,849.23**	**10,891.02**	**15,425.31**	**112,964.91**
A. Mineral Products	56,690.40	NA,NO	NA,NO				56,690.40
B. Chemical Industry	4,145.10	302.55	8,298.10	NA	NA	NA	12,745.75
C. Metal Production	345.76	17.45	NO	IE,NE,NO	70.90	114.44	548.55
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				14,993.97	581.22	4,280.27	19,855.46
F. Consumption of Halocarbons and SF_6 [(2)]				1,855.26	10,238.90	11,030.59	23,124.75
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**438.02**				**438.02**
4. Agriculture		**17,728.58**	**11,020.65**				**28,749.24**
A. Enteric Fermentation		7,572.61					7,572.61
B. Manure Management		2,799.76	3,072.59				5,872.35
C. Rice Cultivation		7,263.40					7,263.40
D. Agricultural Soils [(3)]		NA	7,922.57				7,922.57
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		92.82	25.49				118.31
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [(1)]	**-79,019.48**	**17.88**	**56.74**				**-78,944.85**
A. Forest Land	-86,982.76	17.88	2.64				-86,962.24
B. Cropland	2,372.56	NE,NO	54.10				2,426.66
C. Grassland	-361.88	NE,NO	NE,NO				-361.88
D. Wetlands	117.25	NE,NO	NE,NO				117.25
E. Settlements	3,515.06	NE,NO	NE,NO				3,515.06
F. Other Land	2,027.53	NO	NO				2,027.53
G. Other	292.76	NA,NE	NA,NE				292.76
6. Waste	**16,268.90**	**9,626.84**	**3,203.02**				**29,098.76**
A. Solid Waste Disposal on Land	NE,NO	7,284.13					7,284.13
B. Waste-water Handling		2,239.47	1,286.03				3,525.50
C. Waste Incineration	15,566.99	14.49	1,838.39				17,419.87
D. Other	701.91	88.74	78.60				869.26
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	36,093.69	51.04	326.49				36,471.22
Aviation	15,066.49	8.95	149.00				15,224.44
Marine	21,027.20	42.08	177.50				21,246.78
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**17,805.26**						**17,805.26**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,314,837.52
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,235,892.67

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-6 Emissions and Removals in 1995

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,144,217.63**	**29,702.07**	**31,065.49**	**20,260.17**	**14,271.14**	**16,961.45**	**1,256,477.95**
1. Energy	**1,145,820.01**	**2,572.79**	**8,249.19**				**1,156,642.00**
A. Fuel Combustion (Sectoral Approach)	1,145,769.09	963.60	8,249.04				1,154,981.73
1. Energy Industries	344,948.18	34.43	1,413.33				346,395.94
2. Manufacturing Industries and Construction	370,539.38	364.19	1,828.65				372,732.23
3. Transport	251,176.56	306.34	4,655.05				256,137.96
4. Other Sectors	179,104.97	258.64	352.00				179,715.60
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	50.92	1,609.19	0.16				1,660.27
1. Solid Fuels	NE,NO	1,344.00	NE,NO				1,344.00
2. Oil and Natural Gas	50.92	265.19	0.16				316.26
2. Industrial Processes	**61,332.91**	**321.43**	**8,212.71**	**20,260.17**	**14,271.14**	**16,961.45**	**121,359.81**
A. Mineral Products	56,756.12	NA,NO	NA,NO				56,756.12
B. Chemical Industry	4,219.57	303.51	8,212.71	NA	NA	NA	12,735.79
C. Metal Production	357.22	17.92	NO	IE,NE,NO	69.74	119.50	564.38
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				17,445.12	762.85	4,708.30	22,916.27
F. Consumption of Halocarbons and SF_6 (2)				2,815.05	13,438.56	12,133.65	28,387.26
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**437.58**				**437.58**
4. Agriculture		**17,417.78**	**10,748.45**				**28,166.22**
A. Enteric Fermentation		7,489.25					7,489.25
B. Manure Management		2,751.77	3,020.78				5,772.55
C. Rice Cultivation		7,082.74					7,082.74
D. Agricultural Soils(3)		NA	7,701.83				7,701.83
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		94.01	25.84				119.85
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-79,469.70**	**8.73**	**50.65**				**-79,410.32**
A. Forest Land	-87,329.72	8.73	1.64				-87,319.36
B. Cropland	2,322.12	NE,NO	49.01				2,371.13
C. Grassland	-339.93	NE,NO	NE,NO				-339.93
D. Wetlands	360.35	NE,NO	NE,NO				360.35
E. Settlements	3,376.83	NE,NO	NE,NO				3,376.83
F. Other Land	1,837.13	NO	NO				1,837.13
G. Other	303.53	NA,NE	NA,NE				303.53
6. Waste	**16,534.40**	**9,381.35**	**3,366.92**				**29,282.66**
A. Solid Waste Disposal on Land	NE,NO	7,070.17					7,070.17
B. Waste-water Handling		2,207.18	1,306.53				3,513.71
C. Waste Incineration	15,866.57	14.87	1,981.44				17,862.88
D. Other	667.83	89.13	78.95				835.91
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	38,179.77	52.60	346.77				38,579.14
Aviation	16,922.99	10.06	167.36				17,100.41
Marine	21,256.78	42.54	179.42				21,478.73
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,489.30**						**18,489.30**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,335,888.27
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,256,477.95

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-7 Emissions and Removals in 1996

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,152,307.47**	**28,839.69**	**32,109.69**	**19,906.20**	**14,772.09**	**17,535.35**	**1,265,470.48**
1. Energy	**1,157,958.90**	**2,311.77**	**8,422.52**				**1,168,693.19**
A. Fuel Combustion (Sectoral Approach)	1,157,909.53	960.00	8,422.37				1,167,291.91
1. Energy Industries	345,134.72	36.22	1,444.44				346,615.38
2. Manufacturing Industries and Construction	378,811.73	380.76	1,934.44				381,126.93
3. Transport	256,765.16	312.30	4,740.90				261,818.36
4. Other Sectors	177,197.92	230.73	302.59				177,731.24
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	49.37	1,351.76	0.15				1,401.28
1. Solid Fuels	NE,NO	1,088.43	NE,NO				1,088.43
2. Oil and Natural Gas	49.37	263.34	0.15				312.86
2. Industrial Processes	**61,672.09**	**311.18**	**9,220.07**	**19,906.20**	**14,772.09**	**17,535.35**	**123,416.97**
A. Mineral Products	57,088.67	NA,NO	NA,NO				57,088.67
B. Chemical Industry	4,203.43	292.96	9,220.07	NA	NA	NA	13,716.46
C. Metal Production	379.99	18.22	NO	IE,NE,NO	65.88	143.40	607.48
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				16,052.32	1,007.80	4,182.50	21,242.62
F. Consumption of Halocarbons and SF_6 (2)				3,853.88	13,698.41	13,209.45	30,761.74
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**420.94**				**420.94**
4. Agriculture		**17,038.81**	**10,507.56**				**27,546.37**
A. Enteric Fermentation		7,436.41					7,436.41
B. Manure Management		2,718.75	2,986.55				5,705.30
C. Rice Cultivation		6,793.69					6,793.69
D. Agricultural Soils(3)		NA	7,496.17				7,496.17
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		89.96	24.84				114.80
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-84,274.37**	**28.68**	**47.38**				**-84,198.30**
A. Forest Land	-91,302.44	28.68	3.64				-91,270.12
B. Cropland	2,169.98	NE,NO	43.75				2,213.73
C. Grassland	-331.33	NE,NO	NE,NO				-331.33
D. Wetlands	639.57	NE,NO	NE,NO				639.57
E. Settlements	2,563.22	NE,NO	NE,NO				2,563.22
F. Other Land	1,693.89	NO	NO				1,693.89
G. Other	292.74	NA,NE	NA,NE				292.74
6. Waste	**16,950.85**	**9,149.26**	**3,491.21**				**29,591.32**
A. Solid Waste Disposal on Land	NE,NO	6,869.76					6,869.76
B. Waste-water Handling		2,174.74	1,304.56				3,479.30
C. Waste Incineration	16,310.38	15.24	2,107.36				18,432.98
D. Other	640.47	89.52	79.29				809.28
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	30,958.25	36.01	288.02				31,282.28
Aviation	18,441.91	10.96	182.38				18,635.25
Marine	12,516.34	25.05	105.64				12,647.03
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,549.47**						**18,549.47**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,349,668.79
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,265,470.48

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-8 Emissions and Removals in 1997

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1997
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,146,695.83**	**28,008.97**	**32,807.85**	**19,905.11**	**16,187.61**	**14,998.12**	**1,258,603.48**
1. Energy	**1,154,948.65**	**2,227.09**	**8,645.44**				**1,165,821.18**
A. Fuel Combustion (Sectoral Approach)	1,154,900.68	949.79	8,645.29				1,164,495.76
1. Energy Industries	342,054.20	38.05	1,490.11				343,582.36
2. Manufacturing Industries and Construction	381,142.92	362.72	2,063.18				383,568.82
3. Transport	258,754.31	313.50	4,786.34				263,854.16
4. Other Sectors	172,949.24	235.52	305.67				173,490.43
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	47.97	1,277.29	0.15				1,325.42
1. Solid Fuels	NE,NO	1,006.91	NE,NO				1,006.91
2. Oil and Natural Gas	47.97	270.39	0.15				318.51
2. Industrial Processes	**58,981.65**	**260.22**	**9,792.47**	**19,905.11**	**16,187.61**	**14,998.12**	**120,125.17**
A. Mineral Products	54,452.99	NA,NO	NA,NO				54,452.99
B. Chemical Industry	4,144.19	241.89	9,792.47	NA	NA	NA	14,178.54
C. Metal Production	384.48	18.33	NO	IE,NE,NO	59.43	191.20	653.44
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				15,077.99	1,416.80	2,581.20	19,075.99
F. Consumption of Halocarbons and SF_6 (2)				4,827.12	14,711.38	12,225.72	31,764.21
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**404.60**				**404.60**
4. Agriculture		**16,597.24**	**10,343.94**				**26,941.18**
A. Enteric Fermentation		7,392.92					7,392.92
B. Manure Management		2,678.45	2,961.36				5,639.81
C. Rice Cultivation		6,440.28					6,440.28
D. Agricultural Soils(3)		NA	7,358.79				7,358.79
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		85.58	23.79				109.37
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-84,781.70**	**34.51**	**42.48**				**-84,704.71**
A. Forest Land	-91,144.85	34.51	4.20				-91,106.13
B. Cropland	2,066.42	NE,NO	38.28				2,104.70
C. Grassland	-312.87	NE,NO	NE,NO				-312.87
D. Wetlands	121.50	NE,NO	NE,NO				121.50
E. Settlements	2,145.81	NE,NO	NE,NO				2,145.81
F. Other Land	2,038.63	NO	NO				2,038.63
G. Other	303.65	NA,NE	NA,NE				303.65
6. Waste	**17,547.22**	**8,889.92**	**3,578.92**				**30,016.06**
A. Solid Waste Disposal on Land	NE,NO	6,641.40					6,641.40
B. Waste-water Handling		2,143.20	1,316.27				3,459.47
C. Waste Incineration	16,891.99	14.71	2,182.40				19,089.10
D. Other	655.23	90.61	80.25				826.09
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	35,432.29	43.98	326.77				35,803.04
Aviation	19,134.37	11.37	189.23				19,334.97
Marine	16,297.92	32.61	137.54				16,468.07
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**19,109.13**						**19,109.13**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,343,308.19
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,258,603.48

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-9 Emissions and Removals in 1998

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,111,222.69**	**27,188.55**	**31,294.15**	**19,415.96**	**13,401.73**	**13,624.11**	**1,216,147.19**
1. Energy	**1,125,032.90**	**2,058.84**	**8,509.69**				**1,135,601.42**
A. Fuel Combustion (Sectoral Approach)	1,124,990.17	920.27	8,509.55				1,134,419.99
1. Energy Industries	332,405.28	39.83	1,515.22				333,960.34
2. Manufacturing Industries and Construction	357,838.95	325.35	1,988.70				360,153.00
3. Transport	257,884.68	302.60	4,681.90				262,869.18
4. Other Sectors	176,861.25	252.49	323.73				177,437.47
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	42.73	1,138.57	0.13				1,181.43
1. Solid Fuels	NE,NO	873.05	NE,NO				873.05
2. Oil and Natural Gas	42.73	265.52	0.13				308.38
2. Industrial Processes	**53,317.07**	**242.90**	**8,577.87**	**19,415.96**	**13,401.73**	**13,624.11**	**108,579.64**
A. Mineral Products	49,384.13	NA,NO	NA,NO				49,384.13
B. Chemical Industry	3,639.82	226.75	8,577.87	NA	NA	NA	12,444.45
C. Metal Production	293.11	16.15	NO	IE,NE,NO	49.40	406.30	764.96
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				14,053.43	1,389.50	2,103.20	17,546.13
F. Consumption of Halocarbons and SF_6 [(2)]				5,362.53	11,962.83	11,114.61	28,439.97
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**377.05**				**377.05**
4. Agriculture		**16,302.37**	**10,220.81**				**26,523.18**
A. Enteric Fermentation		7,356.83					7,356.83
B. Manure Management		2,634.57	2,939.73				5,574.30
C. Rice Cultivation		6,229.14					6,229.14
D. Agricultural Soils[(3)]		NA	7,258.12				7,258.12
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		81.84	22.96				104.80
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[(1)]	**-84,647.46**	**10.73**	**36.88**				**-84,599.85**
A. Forest Land	-90,983.32	10.73	1.76				-90,970.82
B. Cropland	2,071.14	NE,NO	35.12				2,106.26
C. Grassland	-290.46	NE,NO	NE,NO				-290.46
D. Wetlands	487.08	NE,NO	NE,NO				487.08
E. Settlements	2,108.68	NE,NO	NE,NO				2,108.68
F. Other Land	1,659.42	NO	NO				1,659.42
G. Other	300.00	NA,NE	NA,NE				300.00
6. Waste	**17,520.19**	**8,573.71**	**3,571.85**				**29,665.75**
A. Solid Waste Disposal on Land	NE,NO	6,370.39					6,370.39
B. Waste-water Handling		2,098.97	1,305.22				3,404.19
C. Waste Incineration	16,911.07	14.53	2,187.07				19,112.67
D. Other	609.12	89.83	79.56				778.50
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	37,361.08	46.63	344.33				37,752.04
Aviation	20,001.55	11.89	197.80				20,211.24
Marine	17,359.53	34.74	146.53				17,540.80
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**17,558.45**						**17,558.45**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,300,747.04
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,216,147.19

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-10 Emissions and Removals in 1999

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,145,857.00**	**26,567.65**	**24,896.58**	**19,934.46**	**10,428.82**	**9,309.93**	**1,236,994.44**
1. Energy	**1,160,147.36**	**2,048.38**	**8,716.26**				**1,170,911.99**
A. Fuel Combustion (Sectoral Approach)	1,160,109.30	947.86	8,716.14				1,169,773.29
1. Energy Industries	349,785.30	42.69	1,615.89				351,443.88
2. Manufacturing Industries and Construction	365,074.78	327.91	2,073.70				367,476.39
3. Transport	260,060.98	301.56	4,667.98				265,030.52
4. Other Sectors	185,188.24	275.70	358.57				185,822.51
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	38.06	1,100.52	0.12				1,138.70
1. Solid Fuels	NE,NO	837.79	NE,NO				837.79
2. Oil and Natural Gas	38.06	262.73	0.12				300.91
2. Industrial Processes	**53,320.07**	**235.76**	**2,000.86**	**19,934.46**	**10,428.82**	**9,309.93**	**95,229.89**
A. Mineral Products	49,100.52	NA,NO	NA,NO				49,100.52
B. Chemical Industry	3,965.06	219.67	2,000.86	NA	NA	NA	6,185.59
C. Metal Production	254.49	16.08	NO	IE,NE,NO	29.12	645.30	944.99
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				14,260.55	1,270.88	1,529.60	17,061.03
F. Consumption of Halocarbons and SF_6 [(2)]				5,673.90	9,128.81	7,135.03	21,937.75
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**362.53**				**362.53**
4. Agriculture		**15,985.34**	**10,167.59**				**26,152.93**
A. Enteric Fermentation		7,300.73					7,300.73
B. Manure Management		2,581.14	2,943.39				5,524.53
C. Rice Cultivation		6,024.77					6,024.77
D. Agricultural Soils[(3)]		NA	7,201.99				7,201.99
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		78.70	22.21				100.91
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[(1)]	**-84,940.27**	**5.25**	**33.45**				**-84,901.56**
A. Forest Land	-90,824.40	5.25	1.21				-90,817.93
B. Cropland	2,026.10	NE,NO	32.24				2,058.34
C. Grassland	-278.22	NE,NO	NE,NO				-278.22
D. Wetlands	458.84	NE,NO	NE,NO				458.84
E. Settlements	1,678.94	NE,NO	NE,NO				1,678.94
F. Other Land	1,704.91	NO	NO				1,704.91
G. Other	293.57	NA,NE	NA,NE				293.57
6. Waste	**17,329.84**	**8,292.92**	**3,615.89**				**29,238.65**
A. Solid Waste Disposal on Land	NE,NO	6,114.02					6,114.02
B. Waste-water Handling		2,074.44	1,274.85				3,349.30
C. Waste Incineration	16,677.27	14.04	2,260.95				18,952.25
D. Other	652.58	90.42	80.09				823.09
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
Memo Items: [(4)]							
International Bunkers	36,022.49	44.55	332.43				36,399.47
Aviation	19,576.46	11.63	193.60				19,781.70
Marine	16,446.03	32.92	138.83				16,617.77
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,261.99**						**18,261.99**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,321,896.00
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,236,994.44

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-11 Emissions and Removals in 2000

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,165,774.11**	**26,006.51**	**27,521.22**	**18,800.43**	**9,583.35**	**7,188.49**	**1,254,874.12**
1. Energy	**1,180,079.82**	**1,980.23**	**8,742.34**				**1,190,802.39**
A. Fuel Combustion (Sectoral Approach)	1,180,043.79	957.04	8,742.22				1,189,743.06
1. Energy Industries	357,574.13	42.61	1,699.98				359,316.71
2. Manufacturing Industries and Construction	376,777.84	354.48	2,116.40				379,248.72
3. Transport	259,138.24	296.62	4,569.99				264,004.85
4. Other Sectors	186,553.58	263.33	355.86				187,172.77
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	36.03	1,023.20	0.11				1,059.34
1. Solid Fuels	NE,NO	749.17	NE,NO				749.17
2. Oil and Natural Gas	36.03	274.02	0.11				310.16
2. Industrial Processes	**53,887.04**	**195.34**	**4,690.09**	**18,800.43**	**9,583.35**	**7,188.49**	**94,344.74**
A. Mineral Products	49,745.61	NA,NO	NA,NO				49,745.61
B. Chemical Industry	3,893.01	178.50	4,690.09	NA	NA	NA	8,761.59
C. Metal Production	248.42	16.84	NO	IE,NE,NO	17.78	1,027.70	1,310.74
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				12,659.84	1,359.00	860.40	14,879.24
F. Consumption of Halocarbons and SF_6 (2)				6,140.59	8,206.56	5,300.39	19,647.55
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**340.99**				**340.99**
4. Agriculture		**15,800.64**	**10,151.36**				**25,952.00**
A. Enteric Fermentation		7,265.44					7,265.44
B. Manure Management		2,538.35	2,983.00				5,521.34
C. Rice Cultivation		5,919.76					5,919.76
D. Agricultural Soils(3)		NA	7,146.58				7,146.58
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		77.10	21.78				98.88
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-85,686.61**	**7.78**	**30.40**				**-85,648.44**
A. Forest Land	-90,663.91	7.78	1.48				-90,654.64
B. Cropland	1,867.20	NE,NO	28.91				1,896.12
C. Grassland	-281.88	NE,NO	NE,NO				-281.88
D. Wetlands	428.72	NE,NO	NE,NO				428.72
E. Settlements	1,279.83	NE,NO	NE,NO				1,279.83
F. Other Land	1,350.52	NO	NO				1,350.52
G. Other	332.90	NA,NE	NA,NE				332.90
6. Waste	**17,493.86**	**8,022.52**	**3,566.05**				**29,082.43**
A. Solid Waste Disposal on Land	NE,NO	5,874.95					5,874.95
B. Waste-water Handling		2,042.76	1,243.51				3,286.28
C. Waste Incineration	16,837.95	13.33	2,241.52				19,092.80
D. Other	655.91	91.47	81.02				828.41
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	36,731.88	46.01	336.87				37,114.77
Aviation	19,542.61	11.61	191.78				19,746.00
Marine	17,189.28	34.40	145.09				17,368.76
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,848.04**						**18,848.04**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,340,522.55
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,254,874.12

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-12 Emissions and Removals in 2001

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,150,450.93**	**25,108.96**	**24,200.06**	**16,168.06**	**7,953.56**	**5,962.42**	**1,229,843.99**
1. Energy	**1,167,417.49**	**1,763.46**	**8,727.72**				**1,177,908.66**
A. Fuel Combustion (Sectoral Approach)	1,167,385.05	925.28	8,727.62				1,177,037.95
1. Energy Industries	349,730.24	41.60	1,912.31				351,684.15
2. Manufacturing Industries and Construction	366,481.38	333.42	2,070.37				368,885.16
3. Transport	261,213.84	290.95	4,390.04				265,894.84
4. Other Sectors	189,959.59	259.31	354.90				190,573.80
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	32.44	838.18	0.10				870.72
1. Solid Fuels	NE,NO	570.30	NE,NO				570.30
2. Oil and Natural Gas	32.44	267.88	0.10				300.42
2. Industrial Processes	**52,657.08**	**147.05**	**1,414.89**	**16,168.06**	**7,953.56**	**5,962.42**	**84,303.06**
A. Mineral Products	48,847.78	NA,NO	NA,NO				48,847.78
B. Chemical Industry	3,598.60	131.21	1,414.89	NA	NA	NA	5,144.70
C. Metal Production	210.71	15.84	NO	IE,NE,NO	15.73	1,147.20	1,389.48
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				9,713.43	1,082.60	788.70	11,584.73
F. Consumption of Halocarbons and SF_6 (2)				6,454.63	6,855.24	4,026.52	17,336.38
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**343.60**				**343.60**
4. Agriculture		**15,615.60**	**10,163.38**				**25,778.98**
A. Enteric Fermentation		7,222.66					7,222.66
B. Manure Management		2,507.22	3,064.07				5,571.29
C. Rice Cultivation		5,810.23					5,810.23
D. Agricultural Soils(3)		NA	7,077.98				7,077.98
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		75.49	21.33				96.82
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-85,869.59**	**12.42**	**27.83**				**-85,829.34**
A. Forest Land	-90,507.39	12.42	1.93				-90,493.04
B. Cropland	1,803.40	NE,NO	25.90				1,829.30
C. Grassland	-272.34	NE,NO	NE,NO				-272.34
D. Wetlands	389.24	NE,NO	NE,NO				389.24
E. Settlements	1,029.45	NE,NO	NE,NO				1,029.45
F. Other Land	1,440.71	NO	NO				1,440.71
G. Other	247.35	NA,NE	NA,NE				247.35
6. Waste	**16,245.95**	**7,570.42**	**3,522.64**				**27,339.01**
A. Solid Waste Disposal on Land	NE,NO	5,615.90					5,615.90
B. Waste-water Handling		1,849.17	1,270.85				3,120.02
C. Waste Incineration	15,615.42	12.61	2,169.64				17,797.66
D. Other	630.53	92.75	82.15				805.43
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**
Memo Items: (4)							
International Bunkers	33,571.42	40.84	309.05				33,921.32
Aviation	18,721.34	11.13	183.72				18,916.19
Marine	14,850.08	29.72	125.33				15,005.12
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**17,205.82**						**17,205.82**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,315,673.33
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,229,843.99

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-13 Emissions and Removals in 2002

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,186,323.87**	**24,198.66**	**23,567.92**	**13,693.03**	**7,433.60**	**5,579.50**	**1,260,796.59**
1. Energy	**1,207,919.26**	**1,321.00**	**8,409.81**				**1,217,650.07**
A. Fuel Combustion (Sectoral Approach)	1,207,888.33	914.56	8,409.71				1,217,212.60
1. Energy Industries	381,372.56	32.36	1,837.01				383,241.93
2. Manufacturing Industries and Construction	372,969.32	343.33	2,083.06				375,395.71
3. Transport	255,606.57	280.27	4,126.51				260,013.34
4. Other Sectors	197,939.88	258.60	363.13				198,561.61
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	30.94	406.44	0.10				437.47
1. Solid Fuels	NE,NO	118.34	NE,NO				118.34
2. Oil and Natural Gas	30.94	288.10	0.10				319.13
2. Industrial Processes	**49,841.06**	**141.08**	**1,238.77**	**13,693.03**	**7,433.60**	**5,579.50**	**77,927.04**
A. Mineral Products	46,234.63	NA,NO	NA,NO				46,234.63
B. Chemical Industry	3,385.48	124.44	1,238.77	NA	NA	NA	4,748.70
C. Metal Production	220.95	16.64	NO	IE,NE,NO	14.83	1,123.30	1,375.72
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				6,456.62	1,009.92	860.40	8,326.94
F. Consumption of Halocarbons and SF_6 (2)				7,236.41	6,408.85	3,595.80	17,241.05
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**334.05**				**334.05**
4. Agriculture		**15,423.94**	**10,196.49**				**25,620.43**
A. Enteric Fermentation		7,175.89					7,175.89
B. Manure Management		2,482.62	3,152.23				5,634.85
C. Rice Cultivation		5,693.94					5,693.94
D. Agricultural Soils(3)		NA	7,024.02				7,024.02
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		71.50	20.24				91.74
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-87,072.73**	**20.59**	**24.91**				**-87,027.22**
A. Forest Land	-90,346.99	20.59	2.76				-90,323.63
B. Cropland	1,765.99	NE,NO	22.15				1,788.14
C. Grassland	-252.08	NE,NO	NE,NO				-252.08
D. Wetlands	95.51	NE,NO	NE,NO				95.51
E. Settlements	120.06	NE,NO	NE,NO				120.06
F. Other Land	1,274.85	NO	NO				1,274.85
G. Other	269.92	NA,NE	NA,NE				269.92
6. Waste	**15,636.28**	**7,292.05**	**3,363.89**				**26,292.22**
A. Solid Waste Disposal on Land	NE,NO	5,354.24					5,354.24
B. Waste-water Handling		1,803.39	1,274.65				3,078.04
C. Waste Incineration	15,059.23	19.51	1,987.46				17,066.21
D. Other	577.05	114.91	101.77				793.73
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	36,728.93	43.74	339.03				37,111.70
Aviation	21,149.32	12.57	207.55				21,369.44
Marine	15,579.61	31.17	131.47				15,742.26
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**17,919.32**						**17,919.32**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,347,823.81
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,260,796.59

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-14 Emissions and Removals in 2003

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,182,275.05**	**23,691.02**	**23,297.73**	**13,761.68**	**7,178.70**	**5,253.91**	**1,255,458.09**
1. Energy	**1,213,922.87**	**1,281.16**	**8,110.92**				**1,223,314.95**
A. Fuel Combustion (Sectoral Approach)	1,213,888.39	891.78	8,110.81				1,222,890.98
1. Energy Industries	395,368.37	31.99	1,863.14				397,263.50
2. Manufacturing Industries and Construction	373,173.39	368.26	2,050.47				375,592.12
3. Transport	253,106.57	268.03	3,853.84				257,228.44
4. Other Sectors	192,240.07	223.50	343.35				192,806.92
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	34.48	389.38	0.11				423.97
1. Solid Fuels	NE,NO	93.86	NE,NO				93.86
2. Oil and Natural Gas	34.48	295.52	0.11				330.11
2. Industrial Processes	**49,010.32**	**133.41**	**1,259.55**	**13,761.68**	**7,178.70**	**5,253.91**	**76,597.58**
A. Mineral Products	45,640.14	NA,NO	NA,NO				45,640.14
B. Chemical Industry	3,128.60	116.91	1,259.55	NA	NA	NA	4,505.06
C. Metal Production	241.57	16.50	NO	IE,NE,NO	15.21	1,125.53	1,398.81
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				5,459.50	965.60	812.60	7,237.70
F. Consumption of Halocarbons and SF_6 (2)				8,302.18	6,197.90	3,315.79	17,815.86
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**320.83**				**320.83**
4. Agriculture		**15,266.48**	**10,204.82**				**25,471.30**
A. Enteric Fermentation		7,066.34					7,066.34
B. Manure Management		2,441.42	3,231.25				5,672.67
C. Rice Cultivation		5,690.55					5,690.55
D. Agricultural Soils(3)		NA	6,954.29				6,954.29
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		68.18	19.28				87.46
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-96,229.95**	**3.93**	**20.38**				**-96,205.65**
A. Forest Land	-99,122.20	3.93	1.10				-99,117.18
B. Cropland	1,760.09	NE,NO	19.28				1,779.37
C. Grassland	-234.17	NE,NO	NE,NO				-234.17
D. Wetlands	63.17	NE,NO	NE,NO				63.17
E. Settlements	2.86	NE,NO	NE,NO				2.86
F. Other Land	1,053.90	NO	NO				1,053.90
G. Other	246.40	NA,NE	NA,NE				246.40
6. Waste	**15,571.81**	**7,006.04**	**3,381.23**				**25,959.07**
A. Solid Waste Disposal on Land	NE,NO	5,090.58					5,090.58
B. Waste-water Handling		1,765.11	1,278.10				3,043.22
C. Waste Incineration	15,055.29	16.79	1,984.84				17,056.92
D. Other	516.53	133.55	118.29				768.36
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	37,506.71	46.37	344.55				37,897.63
Aviation	20,387.64	12.12	200.08				20,599.83
Marine	17,119.07	34.25	144.47				17,297.79
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,298.45**						**18,298.45**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,351,663.74
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,255,458.09

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-15 Emissions and Removals in 2004

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs [2]	PFCs [2]	SF_6 [2]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [1]	**1,182,085.38**	**23,275.39**	**23,384.04**	**10,552.49**	**7,478.43**	**5,095.89**	**1,251,871.61**
1. Energy	**1,214,021.73**	**1,265.39**	**7,817.48**				**1,223,104.61**
A. Fuel Combustion (Sectoral Approach)	1,213,986.74	892.43	7,817.37				1,222,696.54
1. Energy Industries	390,980.48	30.07	1,855.33				392,865.88
2. Manufacturing Industries and Construction	378,734.31	382.75	2,070.73				381,187.79
3. Transport	252,586.69	247.83	3,545.85				256,380.38
4. Other Sectors	191,685.26	231.77	345.46				192,262.49
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	34.99	372.96	0.11				408.07
1. Solid Fuels	NE,NO	66.51	NE,NO				66.51
2. Oil and Natural Gas	34.99	306.45	0.11				341.56
2. Industrial Processes	**48,837.57**	**143.10**	**1,657.60**	**10,552.49**	**7,478.43**	**5,095.89**	**73,765.07**
A. Mineral Products	45,407.93	NA,NO	NA,NO				45,407.93
B. Chemical Industry	3,171.80	126.10	1,657.60	NA	NA	NA	4,955.50
C. Metal Production	257.84	17.01	NO	IE,NE,NO	14.80	1,111.02	1,400.67
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				1,469.74	866.84	764.80	3,101.38
F. Consumption of Halocarbons and SF_6 [2]				9,082.75	6,596.78	3,220.06	18,899.60
G. Other	NO	NO	NO	NO	NO	NO	NO
3. Solvent and Other Product Use	**NA,NE**		**297.54**				**297.54**
4. Agriculture		**15,145.21**	**10,215.54**				**25,360.75**
A. Enteric Fermentation		6,970.65					6,970.65
B. Manure Management		2,395.90	3,309.21				5,705.12
C. Rice Cultivation		5,712.00					5,712.00
D. Agricultural Soils [3]		NA	6,887.52				6,887.52
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		66.65	18.81				85.46
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [1]	**-95,798.26**	**12.13**	**17.77**				**-95,768.36**
A. Forest Land	-98,608.75	12.13	1.91				-98,594.71
B. Cropland	1,720.21	NE,NO	15.87				1,736.07
C. Grassland	-216.92	NE,NO	NE,NO				-216.92
D. Wetlands	56.76	NE,NO	NE,NO				56.76
E. Settlements	9.36	NE,NO	NE,NO				9.36
F. Other Land	1,004.78	NO	NO				1,004.78
G. Other	236.30	NA,NE	NA,NE				236.30
6. Waste	**15,024.34**	**6,709.56**	**3,378.10**				**25,112.00**
A. Solid Waste Disposal on Land	NE,NO	4,824.66					4,824.66
B. Waste-water Handling		1,732.24	1,281.61				3,013.85
C. Waste Incineration	14,517.64	15.38	1,974.89				16,507.92
D. Other	506.70	137.29	121.60				765.58
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: [4]							
International Bunkers	39,113.12	48.45	359.20				39,520.78
Aviation	21,190.20	12.59	207.95				21,410.75
Marine	17,922.92	35.86	151.25				18,110.03
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**18,190.54**						**18,190.54**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,347,639.97
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,251,871.61

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-16 Emissions and Removals in 2005

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2005
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,192,774.25**	**22,926.52**	**22,973.48**	**10,518.22**	**6,990.73**	**4,807.94**	**1,260,991.14**
1. Energy	**1,217,734.50**	**1,298.18**	**7,749.44**				**1,226,782.12**
A. Fuel Combustion (Sectoral Approach)	1,217,696.90	911.09	7,749.33				1,226,357.32
1. Energy Industries	406,038.52	31.44	2,067.72				408,137.69
2. Manufacturing Industries and Construction	371,229.41	387.00	2,036.13				373,652.54
3. Transport	247,211.90	234.89	3,294.09				250,740.89
4. Other Sectors	193,217.06	257.76	351.38				193,826.20
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	37.60	387.09	0.12				424.80
1. Solid Fuels	NE,NO	64.91	NE,NO				64.91
2. Oil and Natural Gas	37.60	322.18	0.12				359.90
2. Industrial Processes	**49,902.66**	**133.41**	**1,299.94**	**10,518.22**	**6,990.73**	**4,807.94**	**73,652.90**
A. Mineral Products	46,773.88	NA,NO	NA,NO				46,773.88
B. Chemical Industry	2,886.85	116.52	1,299.94	NA	NA	NA	4,303.32
C. Metal Production	241.93	16.89	NO	IE,NE,NO	14.80	1,157.31	1,430.93
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				816.01	837.49	975.12	2,628.62
F. Consumption of Halocarbons and SF_6 (2)				9,702.21	6,138.44	2,675.51	18,516.16
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**266.41**				**266.41**
4. Agriculture		**15,063.59**	**10,199.62**				**25,263.21**
A. Enteric Fermentation		6,911.89					6,911.89
B. Manure Management		2,347.12	3,401.51				5,748.64
C. Rice Cultivation		5,739.10					5,739.10
D. Agricultural Soils (3)		NA	6,779.61				6,779.61
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		65.48	18.49				83.97
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry (1)	**-89,354.20**	**9.18**	**14.79**				**-89,330.23**
A. Forest Land	-92,469.17	9.18	1.60				-92,458.39
B. Cropland	1,754.44	NE,NO	13.19				1,767.63
C. Grassland	-200.66	NE,NO	NE,NO				-200.66
D. Wetlands	14.71	NE,NO	NE,NO				14.71
E. Settlements	314.94	NE,NO	NE,NO				314.94
F. Other Land	1,000.26	NO	NO				1,000.26
G. Other	231.29	NA,NE	NA,NE				231.29
6. Waste	**14,491.29**	**6,422.16**	**3,443.27**				**24,356.72**
A. Solid Waste Disposal on Land	NE,NO	4,567.83					4,567.83
B. Waste-water Handling		1,684.67	1,263.26				2,947.93
C. Waste Incineration	13,984.48	14.27	2,042.38				16,041.12
D. Other	506.81	155.39	137.64				799.84
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	41,564.88	53.16	380.11				41,998.14
Aviation	21,336.33	12.68	209.39				21,558.39
Marine	20,228.55	40.48	170.72				20,439.75
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**21,745.66**						**21,745.66**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,350,321.36
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,260,991.14

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-17 Emissions and Removals in 2006

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,179,656.95**	**22,576.16**	**23,036.31**	**11,742.22**	**7,311.27**	**4,910.86**	**1,249,233.77**
1. Energy	**1,199,340.38**	**1,323.79**	**7,516.60**				**1,208,180.77**
A. Fuel Combustion (Sectoral Approach)	1,199,304.49	915.54	7,516.49				1,207,736.52
1. Energy Industries	394,358.50	31.44	2,046.29				396,436.23
2. Manufacturing Industries and Construction	373,314.51	412.22	2,009.30				375,736.03
3. Transport	243,855.38	218.87	3,114.68				247,188.93
4. Other Sectors	187,776.10	253.01	346.21				188,375.33
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	35.89	408.25	0.11				444.26
1. Solid Fuels	NE,NO	68.12	NE,NO				68.12
2. Oil and Natural Gas	35.89	340.14	0.11				376.14
2. Industrial Processes	**49,975.18**	**132.62**	**1,624.72**	**11,742.22**	**7,311.27**	**4,910.86**	**75,696.86**
A. Mineral Products	46,878.88	NA,NO	NA,NO				46,878.88
B. Chemical Industry	2,918.74	115.46	1,624.72	NA	NA	NA	4,658.93
C. Metal Production	177.55	17.16	NO	IE,NE,NO	14.82	1,091.08	1,300.62
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				938.25	879.14	1,366.36	3,183.75
F. Consumption of Halocarbons and SF_6 (2)				10,803.97	6,417.30	2,453.41	19,674.68
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**242.34**				**242.34**
4. Agriculture		**14,990.38**	**10,306.41**				**25,296.79**
A. Enteric Fermentation		6,912.22					6,912.22
B. Manure Management		2,305.61	3,513.70				5,819.31
C. Rice Cultivation		5,707.49					5,707.49
D. Agricultural Soils(3)		NA	6,774.35				6,774.35
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		65.06	18.36				83.42
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-83,313.78**	**2.44**	**12.47**				**-83,298.86**
A. Forest Land	-86,597.28	2.44	0.97				-86,593.87
B. Cropland	1,766.92	NE,NO	11.50				1,778.42
C. Grassland	-201.79	NE,NO	NE,NO				-201.79
D. Wetlands	22.05	NE,NO	NE,NO				22.05
E. Settlements	671.74	NE,NO	NE,NO				671.74
F. Other Land	794.22	NO	NO				794.22
G. Other	230.36	NA,NE	NA,NE				230.36
6. Waste	**13,655.17**	**6,126.92**	**3,333.77**				**23,115.86**
A. Solid Waste Disposal on Land	NE,NO	4,300.58					4,300.58
B. Waste-water Handling		1,651.99	1,273.62				2,925.61
C. Waste Incineration	13,132.81	13.29	1,917.49				15,063.59
D. Other	522.36	161.06	142.66				826.08
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	38,991.92	49.94	356.50				39,398.36
Aviation	19,964.61	11.87	195.93				20,172.40
Marine	19,027.31	38.07	160.58				19,225.96
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**21,979.06**						**21,979.06**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,332,532.63
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,249,233.77

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-18 Emissions and Removals in 2007

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,213,705.98**	**22,167.91**	**21,860.96**	**13,279.24**	**6,400.59**	**4,407.45**	**1,281,822.13**
1. Energy	**1,233,404.30**	**1,333.82**	**7,473.79**				**1,242,211.92**
A. Fuel Combustion (Sectoral Approach)	1,233,366.78	917.63	7,473.68				1,241,758.08
1. Energy Industries	447,301.91	34.15	2,096.39				449,432.44
2. Manufacturing Industries and Construction	370,259.27	438.66	2,063.01				372,760.95
3. Transport	238,065.44	204.35	2,979.03				241,248.82
4. Other Sectors	177,740.16	240.48	335.24				178,315.87
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	37.53	416.20	0.12				453.84
1. Solid Fuels	NE,NO	51.48	NE,NO				51.48
2. Oil and Natural Gas	37.53	364.72	0.12				402.37
2. Industrial Processes	**49,212.77**	**133.66**	**860.18**	**13,279.24**	**6,400.59**	**4,407.45**	**74,293.90**
A. Mineral Products	46,010.32	NA,NO	NA,NO				46,010.32
B. Chemical Industry	2,990.43	116.36	860.18	NA	NA	NA	3,966.97
C. Metal Production	212.02	17.30	NO	IE,NE,NO	14.69	1,089.34	1,333.35
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				497.61	783.02	1,198.82	2,479.45
F. Consumption of Halocarbons and SF_6 [(2)]				12,781.64	5,602.88	2,119.29	20,503.80
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**159.95**				**159.95**
4. Agriculture		**14,864.27**	**10,202.90**				**25,067.16**
A. Enteric Fermentation		6,888.47					6,888.47
B. Manure Management		2,260.09	3,631.17				5,891.27
C. Rice Cultivation		5,652.17					5,652.17
D. Agricultural Soils[(3)]		NA	6,553.83				6,553.83
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		63.53	17.89				81.42
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[(1)]	**-82,448.67**	**2.04**	**11.07**				**-82,435.56**
A. Forest Land	-85,331.32	2.04	0.86				-85,328.41
B. Cropland	1,844.40	NE,NO	10.21				1,854.60
C. Grassland	-169.16	NE,NO	NE,NO				-169.16
D. Wetlands	56.69	NE,NO	NE,NO				56.69
E. Settlements	515.55	NE,NO	NE,NO				515.55
F. Other Land	310.17	NO	NO				310.17
G. Other	325.00	NA,NE	NA,NE				325.00
6. Waste	**13,537.58**	**5,834.11**	**3,153.06**				**22,524.76**
A. Solid Waste Disposal on Land	NE,NO	4,053.64					4,053.64
B. Waste-water Handling		1,611.81	1,252.20				2,864.01
C. Waste Incineration	12,976.38	12.15	1,762.25				14,750.78
D. Other	561.20	156.51	138.62				856.33
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	37,259.15	48.74	339.71				37,647.60
Aviation	18,358.58	10.91	180.16				18,549.66
Marine	18,900.57	37.83	159.54				19,097.94
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**22,960.05**						**22,960.05**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,364,257.69
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,281,822.13

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-19 Emissions and Removals in 2008

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS (Sheet 1 of 1)

Inventory 2008
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,136,298.79**	**21,695.91**	**21,733.87**	**15,298.88**	**4,615.07**	**3,761.22**	**1,203,403.73**
1. Energy	**1,153,082.62**	**1,295.20**	**7,154.92**				**1,161,532.74**
A. Fuel Combustion (Sectoral Approach)	1,153,044.77	886.91	7,154.80				1,161,086.48
1. Energy Industries	420,888.41	31.44	2,022.27				422,942.12
2. Manufacturing Industries and Construction	335,621.02	437.79	1,988.48				338,047.28
3. Transport	228,349.14	188.01	2,822.29				231,359.44
4. Other Sectors	168,186.20	229.66	321.77				168,737.63
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	37.85	408.29	0.12				446.26
1. Solid Fuels	NE,NO	45.83	NE,NO				45.83
2. Oil and Natural Gas	37.85	362.46	0.12				400.43
2. Industrial Processes	**45,613.15**	**120.94**	**1,262.15**	**15,298.88**	**4,615.07**	**3,761.22**	**70,671.41**
A. Mineral Products	42,883.28	NA,NO	NA,NO				42,883.28
B. Chemical Industry	2,574.10	105.92	1,262.15	NA	NA	NA	3,942.17
C. Metal Production	155.77	15.02	NO	IE,NE,NO	14.67	652.47	837.94
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				702.00	523.80	1,288.21	2,514.01
F. Consumption of Halocarbons and SF_6 [(2)]				14,596.89	4,076.60	1,820.54	20,494.02
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**129.10**				**129.10**
4. Agriculture		**14,712.00**	**10,074.67**				**24,786.68**
A. Enteric Fermentation		6,829.27					6,829.27
B. Manure Management		2,222.60	3,733.61				5,956.21
C. Rice Cultivation		5,598.59					5,598.59
D. Agricultural Soils[(3)]		NA	6,323.82				6,323.82
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		61.54	17.25				78.78
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry[(1)]	**-77,532.90**	**21.73**	**11.58**				**-77,499.59**
A. Forest Land	-80,334.74	21.73	2.68				-80,310.33
B. Cropland	1,715.77	NE,NO	8.90				1,724.67
C. Grassland	-161.37	NE,NO	NE,NO				-161.37
D. Wetlands	34.53	NE,NO	NE,NO				34.53
E. Settlements	578.70	NE,NO	NE,NO				578.70
F. Other Land	328.47	NO	NO				328.47
G. Other	305.74	NA,NE	NA,NE				305.74
6. Waste	**15,135.92**	**5,546.03**	**3,101.44**				**23,783.38**
A. Solid Waste Disposal on Land	NE,NO	3,767.41					3,767.41
B. Waste-water Handling		1,591.65	1,252.51				2,844.16
C. Waste Incineration	14,605.51	11.82	1,693.79				16,311.12
D. Other	530.41	175.15	155.14				860.70
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	34,849.64	45.09	318.18				35,212.92
Aviation	17,517.99	10.41	171.92				17,700.32
Marine	17,331.65	34.68	146.27				17,512.60
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**21,600.17**						**21,600.17**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,280,903.32
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,203,403.73

[(1)] For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

[(2)] Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

[(3)] Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

[(4)] See footnote 8 to table Summary 1.A.

Table A9-20 Emissions and Removals in 2009

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,068,938.99**	**21,108.94**	**21,454.85**	**16,546.60**	**3,265.25**	**1,851.27**	**1,133,165.90**
1. Energy	**1,088,837.51**	**1,255.13**	**6,816.26**				**1,096,908.89**
A. Fuel Combustion (Sectoral Approach)	1,088,802.36	860.87	6,816.14				1,096,479.37
1. Energy Industries	385,493.08	29.71	1,934.25				387,457.05
2. Manufacturing Industries and Construction	319,093.43	436.44	1,917.26				321,447.13
3. Transport	223,043.03	175.91	2,652.81				225,871.75
4. Other Sectors	161,172.82	218.81	311.82				161,703.45
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	35.15	394.26	0.11				429.52
1. Solid Fuels	NE,NO	46.25	NE,NO				46.25
2. Oil and Natural Gas	35.15	348.01	0.11				383.27
2. Industrial Processes	**40,189.35**	**109.09**	**1,559.50**	**16,546.60**	**3,265.25**	**1,851.27**	**63,521.07**
A. Mineral Products	37,589.16	NA,NO	NA,NO				37,589.16
B. Chemical Industry	2,488.20	96.13	1,559.50	NA	NA	NA	4,143.83
C. Metal Production	111.99	12.96	NO	IE,NE,NO	11.02	239.00	374.97
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				222.14	399.48	260.51	882.13
F. Consumption of Halocarbons and SF_6 (2)				16,324.46	2,854.75	1,351.76	20,530.98
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**120.50**				**120.50**
4. Agriculture		**14,479.74**	**9,924.86**				**24,404.59**
A. Enteric Fermentation		6,691.40					6,691.40
B. Manure Management		2,185.09	3,775.85				5,960.94
C. Rice Cultivation		5,544.83					5,544.83
D. Agricultural Soils (3)		NA	6,132.73				6,132.73
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		58.42	16.28				74.70
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry (1)	**-72,523.94**	**8.61**	**8.59**				**-72,506.74**
A. Forest Land	-75,674.84	8.61	1.37				-75,664.86
B. Cropland	1,861.09	NE,NO	7.22				1,868.31
C. Grassland	-139.47	NE,NO	NE,NO				-139.47
D. Wetlands	73.42	NE,NO	NE,NO				73.42
E. Settlements	766.57	NE,NO	NE,NO				766.57
F. Other Land	319.14	NO	NO				319.14
G. Other	270.15	NA,NE	NA,NE				270.15
6. Waste	**12,436.07**	**5,256.37**	**3,025.16**				**20,717.59**
A. Solid Waste Disposal on Land	NE,NO	3,524.71					3,524.71
B. Waste-water Handling		1,545.11	1,235.85				2,780.97
C. Waste Incineration	11,922.38	10.50	1,633.38				13,566.25
D. Other	513.69	176.05	155.93				845.67
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	30,686.03	39.77	280.09				31,005.89
Aviation	15,372.73	9.14	150.86				15,532.73
Marine	15,313.30	30.64	129.22				15,473.16
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**19,755.88**						**19,755.88**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,205,672.64
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,133,165.90

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-21 Emissions and Removals in 2010

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,118,699.07**	**20,698.99**	**20,776.73**	**18,291.38**	**3,408.71**	**1,862.42**	**1,183,737.31**
1. Energy	**1,137,014.55**	**1,332.95**	**6,720.87**				**1,145,068.37**
A. Fuel Combustion (Sectoral Approach)	1,136,981.41	957.21	6,720.77				1,144,659.39
1. Energy Industries	405,371.75	41.88	1,915.58				407,329.21
2. Manufacturing Industries and Construction	342,657.35	516.47	1,987.88				345,161.71
3. Transport	225,507.56	165.95	2,491.99				228,165.50
4. Other Sectors	163,444.75	232.91	325.32				164,002.98
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	33.14	375.74	0.11				408.98
1. Solid Fuels	NE,NO	44.49	NE,NO				44.49
2. Oil and Natural Gas	33.14	331.25	0.11				364.50
2. Industrial Processes	**41,074.01**	**118.30**	**1,077.74**	**18,291.38**	**3,408.71**	**1,862.42**	**65,832.56**
A. Mineral Products	38,176.92	NA,NO	NA,NO				38,176.92
B. Chemical Industry	2,737.23	103.44	1,077.74	NA	NA	NA	3,918.41
C. Metal Production	159.86	14.87	NO	IE,NE,NO	10.38	307.90	493.01
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				128.34	200.24	198.37	526.96
F. Consumption of Halocarbons and SF_6 (2)				18,163.04	3,198.08	1,356.15	22,717.28
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**98.95**				**98.95**
4. Agriculture		**14,271.62**	**9,938.13**				**24,209.74**
A. Enteric Fermentation		6,576.99					6,576.99
B. Manure Management		2,161.53	3,778.75				5,940.29
C. Rice Cultivation		5,477.13					5,477.13
D. Agricultural Soils(3)		NA	6,143.83				6,143.83
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		55.96	15.54				71.51
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-72,368.18**	**4.14**	**6.66**				**-72,357.39**
A. Forest Land	-75,942.17	4.14	0.99				-75,937.04
B. Cropland	1,757.79	NE,NO	5.66				1,763.45
C. Grassland	-111.87	NE,NO	NE,NO				-111.87
D. Wetlands	51.48	NE,NO	NE,NO				51.48
E. Settlements	1,292.26	NE,NO	NE,NO				1,292.26
F. Other Land	341.44	NO	NO				341.44
G. Other	242.88	NA,NE	NA,NE				242.88
6. Waste	**12,978.70**	**4,971.99**	**2,934.38**				**20,885.07**
A. Solid Waste Disposal on Land	NE,NO	3,292.26					3,292.26
B. Waste-water Handling		1,516.82	1,221.28				2,738.10
C. Waste Incineration	12,451.79	9.69	1,577.39				14,038.87
D. Other	526.91	153.21	135.70				815.83
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	31,179.83	39.46	285.52				31,504.81
Aviation	16,295.33	9.68	159.92				16,464.93
Marine	14,884.50	29.78	125.60				15,039.88
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**29,847.34**						**29,847.34**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,256,094.69
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,183,737.31

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-22 Emissions and Removals in 2011

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2011
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	HFCs (2)	PFCs (2)	SF_6 (2)	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) (1)	**1,165,032.89**	**20,292.00**	**20,499.64**	**20,451.53**	**3,016.35**	**1,637.85**	**1,230,930.27**
1. Energy	**1,186,969.92**	**1,310.42**	**6,725.94**				**1,195,006.28**
A. Fuel Combustion (Sectoral Approach)	1,186,937.39	935.98	6,725.84				1,194,599.21
1. Energy Industries	466,935.31	68.65	2,063.57				469,067.53
2. Manufacturing Industries and Construction	334,882.52	511.83	1,966.62				337,360.97
3. Transport	221,559.12	157.70	2,367.14				224,083.95
4. Other Sectors	163,560.44	197.80	328.51				164,086.76
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	32.52	374.43	0.10				407.06
1. Solid Fuels	NE,NO	44.66	NE,NO				44.66
2. Oil and Natural Gas	32.52	329.77	0.10				362.40
2. Industrial Processes	**41,182.35**	**119.59**	**787.56**	**20,451.53**	**3,016.35**	**1,637.85**	**67,195.24**
A. Mineral Products	38,391.41	NA,NO	NA,NO				38,391.41
B. Chemical Industry	2,629.25	104.50	787.56	NA	NA	NA	3,521.31
C. Metal Production	161.70	15.09	NO	0.91	10.36	191.20	379.25
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				112.52	171.90	138.62	423.05
F. Consumption of Halocarbons and SF_6 (2)				20,338.10	2,834.09	1,308.03	24,480.22
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**97.15**				**97.15**
4. Agriculture		**14,090.97**	**9,935.03**				**24,025.99**
A. Enteric Fermentation		6,440.80					6,440.80
B. Manure Management		2,134.28	3,734.20				5,868.48
C. Rice Cultivation		5,459.77					5,459.77
D. Agricultural Soils(3)		NA	6,185.25				6,185.25
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		56.12	15.58				71.69
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry(1)	**-75,599.01**	**5.35**	**6.01**				**-75,587.65**
A. Forest Land	-77,917.58	5.35	1.09				-77,911.14
B. Cropland	1,709.14	NE,NO	4.92				1,714.06
C. Grassland	-133.05	NE,NO	NE,NO				-133.05
D. Wetlands	43.99	NE,NO	NE,NO				43.99
E. Settlements	156.22	NE,NO	NE,NO				156.22
F. Other Land	295.49	NO	NO				295.49
G. Other	246.78	NA,NE	NA,NE				246.78
6. Waste	**12,479.64**	**4,765.68**	**2,947.95**				**20,193.27**
A. Solid Waste Disposal on Land	NE,NO	3,095.67					3,095.67
B. Waste-water Handling		1,491.43	1,212.87				2,704.30
C. Waste Incineration	11,955.51	9.62	1,585.43				13,550.56
D. Other	524.13	168.96	149.65				842.74
7. Other *(as specified in Summary 1.A)*	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: (4)							
International Bunkers	31,636.35	37.63	292.06				31,966.04
Aviation	18,249.69	10.85	179.10				18,439.64
Marine	13,386.66	26.78	112.96				13,526.40
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**32,484.40**						**32,484.40**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,306,517.92
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,230,930.27

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Table A9-23 Emissions and Removals in 2012

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2014 v1.1
JAPAN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs [(2)]	PFCs [(2)]	SF_6 [(2)]	Total
	CO_2 equivalent (Gg)						
Total (Net Emissions) [(1)]	**1,200,539.05**	**20,008.36**	**20,235.91**	**22,925.68**	**2,758.27**	**1,585.09**	**1,268,052.37**
1. Energy	**1,221,599.84**	**1,285.08**	**6,692.98**				**1,229,577.90**
A. Fuel Combustion (Sectoral Approach)	1,221,568.13	920.34	6,692.88				1,229,181.36
1. Energy Industries	510,263.11	78.21	2,064.96				512,406.28
2. Manufacturing Industries and Construction	333,094.64	497.01	1,988.55				335,580.20
3. Transport	217,308.56	154.67	2,292.05				219,755.28
4. Other Sectors	160,901.83	190.46	347.31				161,439.60
5. Other	NO	NO	NO				NO
B. Fugitive Emissions from Fuels	31.71	364.74	0.10				396.54
1. Solid Fuels	NE,NO	47.33	NE,NO				47.33
2. Oil and Natural Gas	31.71	317.40	0.10				349.21
2. Industrial Processes	**41,495.86**	**119.52**	**631.33**	**22,925.68**	**2,758.27**	**1,585.09**	**69,515.75**
A. Mineral Products	38,905.98	NA,NO	NA,NO				38,905.98
B. Chemical Industry	2,415.68	104.33	631.33	NA	NA	NA	3,151.34
C. Metal Production	174.20	15.19	NO	1.17	9.02	191.20	390.78
D. Other Production	IE						IE
E. Production of Halocarbons and SF_6				92.42	122.16	129.06	343.64
F. Consumption of Halocarbons and SF_6 [(2)]				22,832.09	2,627.09	1,264.83	26,724.02
G. Other	NO	NO	NO	NA,NO	NA,NO	NO	NA,NO
3. Solvent and Other Product Use	**NA,NE**		**90.68**				**90.68**
4. Agriculture		**14,037.20**	**9,867.56**				**23,904.76**
A. Enteric Fermentation		6,378.73					6,378.73
B. Manure Management		2,121.36	3,711.92				5,833.28
C. Rice Cultivation		5,480.40					5,480.40
D. Agricultural Soils [(3)]		NA	6,139.90				6,139.90
E. Prescribed Burning of Savannas		NO	NO				NO
F. Field Burning of Agricultural Residues		56.71	15.74				72.45
G. Other		NO	NO				NO
5. Land Use, Land-Use Change and Forestry [(1)]	**-75,071.64**	**1.59**	**4.70**				**-75,065.36**
A. Forest Land	-77,672.75	1.59	0.71				-77,670.44
B. Cropland	1,641.22	NE,NO	3.98				1,645.20
C. Grassland	-116.01	NE,NO	NE,NO				-116.01
D. Wetlands	31.83	NE,NO	NE,NO				31.83
E. Settlements	508.33	NE,NO	NE,NO				508.33
F. Other Land	288.96	NO	NO				288.96
G. Other	246.78	NA,NE	NA,NE				246.78
6. Waste	**12,514.99**	**4,564.97**	**2,948.67**				**20,028.63**
A. Solid Waste Disposal on Land	NA,NE,NO	2,927.88					2,927.88
B. Waste-water Handling		1,463.83	1,174.88				2,638.72
C. Waste Incineration	11,999.93	8.42	1,627.79				13,636.14
D. Other	515.07	164.83	146.00				825.90
7. Other ***(as specified in Summary 1.A)***	**NA,NO**	**NA,NO**	**NA,NO**	**NA**	**NA**	**NA,NO**	**NA,NO**

Memo Items: [(4)]							
International Bunkers	32,349.06	37.80	299.30				32,686.16
Aviation	19,140.10	11.38	187.83				19,339.31
Marine	13,208.96	26.43	111.46				13,346.85
Multilateral Operations	**NO**	**NO**	**NO**				**NO**
CO_2 Emissions from Biomass	**32,503.57**						**32,503.57**

Total CO_2 Equivalent Emissions without Land Use, Land-Use Change and Forestry	1,343,117.72
Total CO_2 Equivalent Emissions with Land Use, Land-Use Change and Forestry	1,268,052.37

(1) For CO_2 from Land Use, Land-use Change and Forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for emissions positive (+).

(2) Actual emissions should be included in the national totals. If no actual emissions were reported, potential emissions should be included.

(3) Parties which previously reported CO_2 from soils in the Agriculture sector should note this in the NIR.

(4) See footnote 8 to table Summary 1.A.

Abbreviations

1. Greenhouse Gasses

Table 1-1 Six gasses controlled by Kyoto Protocol

Term	Gas
CO_2	Carbon dioxide
CH_4	Methane
N_2O	Nitrous oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulfur hexafluoride

Table 1-2 Indirect gasses and precursors

Term	Gas
NOx	Sum of nitrogen oxide and nitrogen dioxide
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds
SO_2	Sulfur dioxide

2. Prefixes and Units

Table 2-1 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 2-2 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 3-1 Notation keys (See Annex 5)

Notation Key	Definition
NO	Not Occurring
NE	Not Estimated
NA	Not Applicable
IE	Included Elsewhere
C	Confidential

4. Other Abbreviations

Table 4-1 Abbreviations

	Terms	Definition
A	AAU	Assigned Amount Units
	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
	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	EF	Emission Factor
F	FM	Forest Management
	FY	Fiscal Year
G	GCV	Gross Calorific Value
	GHG	Greenhouse Gas
	GIO	Greenhouse Gas Inventory Office
	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	L.D.converter	Linz-Donawitz converter
	LDG	Linz-Donawitz converter Gas
	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
R	RDF	Refuse Derived Fuel
	RPF	Refuse Paper and Plastic Fuel
	RV	Revegetation
T	THC	Total Hydrocarbon
	TOE	Tonnes of Oil Equivalent
U	UNFCCC	United Nations Framework Convention on Climate Change