Chapter 2
Greenhouse Gas Inventory Information

2.1 Outline

On the basis of Article 4.1 (a) of the United Nations Framework Convention on Climate Change, all Parties to the Convention are required to submit national inventories of greenhouse gas emissions and removals to the Secretariat of the Convention. This chapter summarizes Japan's national inventory on emissions and removals of greenhouse gases and precursors from fiscal 1990 through 1999.

The calculation methods and the reporting format of the inventory are in accordance with the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the IPCC (Inter-governmental Panel on Climate Change) (hereafter, 'Revised 1996 IPCC Guidelines') [1]. In general, this inventory was calculated and reported in accordance with these guidelines. In 2000, a 'Good Practice and Uncertainty Management' report [2] was drawn up in which was described calculation selection methods that take into consideration the different circumstances of each country and quantitative assessment methods for uncertainties. It states that each country should try to adopt this reporting procedure for their 2001 report inventory.

In general, this inventory was calculated and reported in accordance with the Revised 1996 IPCC Guidelines. However, some portions were calculated using methods that differ from the methods indicated in the Revised 1996 IPCC Guidelines in order to ensure that the results would reflect national circumstance of Japan. These differences are explained in detail in the relevant sections of this chapter. Application of the 'Good Practice and Uncertainty Management' report is being examined and has not yet been applied to the inventory.

Based on the Guidelines for the Preparation of the Second National Communications by Annex I Parties, as well as the conclusion of Subsidiary Body for Scientific and Technological Advice (SBSTA), emissions from international bunkers were calculated separately and were not included in total greenhouse gas emissions.

The target greenhouse gas source and sink categories and the uncertainties of the estimates are shown in Table 2.1.

The Revised 1996 IPCC Guidelines suggest applying a three-tiered ranking system [H (High), M (Medium), and L (Low)] to evaluate the quality of estimates for each source and sink category. However, these levels are not specifically defined. And, uncertainty assessment methods are indicated in the 'Good Practice and Uncertainty Management' report. However, in Japan, it is being examined. Therefore, evaluation for this report was made using the same standard used in the previous report. In other words, the compilers of this

inventory have provided the three-tiered ranking based on the criteria shown in Table 2.2 in the same way as the second national report.

This chapter presents a comprehensive inventory table of the different target gases treated in each section, based on data dating from 1990 up to the most recent data available. A summary is given concerning emissions and removals of each gas, and an explanation is given concerning estimation methods of major gas emissions. The tables used in this chapter contain minor alterations to the standard forms indicated in the Revised 1996 IPCC Guidelines. For detailed information concerning the calculation and compilation of the inventory on greenhouse gases and the emission and removal categories used, consult the Revised 1996 IPCC Guidelines.

Table 2.1 Greenhouse Gas Source and Sink Categories, and Estimate Quality

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NO_x		CO		NMVOC		SO_2	
	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality	Estimate	Quality
Total National Emissions and Removals		H		L		L		H		H		H		H		M		M		H
1 Energy	ALL	H	ALL	L	PART	L							ALL	H	ALL	M	ALL	L	PART	H
A. Fuel Combustion Activities																				
Reference Approach	ALL	H																		
Sectoral Approach	ALL	H	ALL	L	PART	L							ALL	M	ALL	M	ALL	L	PART	H
1. Energy Industries	ALL	H	ALL	M	ALL	L							ALL	H	ALL	M	ALL	L	ALL	H
2. Manufacturing Industries and Construction	ALL	H	ALL	L	ALL	L							ALL	H	ALL	M	ALL	L	ALL	H
3. Transport	ALL	H	ALL	L	PART	M							ALL	M	ALL	M	ALL	L	PART	H
4. Other Sectors	ALL	H	ALL	L	ALL	L							ALL	M	ALL	M	ALL	L	ALL	H
5. Other	ALL	H	NO	-	NO	-							NO	-	NO	-	NO	-	NO	-
B. Fugitive Emissions from Fuels	NO	-	ALL	L	NO	-							NO	-	NO	-	ALL	L	NO	-
1. Solid Fuels	NO	-	ALL	L	NO	-														
2. Oil and Natural Gas	NO	-	ALL	L	NO	-							NO	-	NO	-	ALL	L	NO	-
2 Industrial Processes	PART	H	PART	L	PART	H	PART	H	PART	H	PART	H	PART	H	NE	-	PART	L	PART	H
A. Mineral Products	PART	H	NO	-	NO	-							PART	H	NE	-	NO	-	PART	H
B. Chemical Industry	PART	H	PART	L	PART	H	NE	-	NE	-			PART	H	NE	-	NO	-	PART	H
C. Metal Production	NE, IE	-	NO, NE	-	NO	-			NE	-	NE	-	PART	H	NE	-	NO	-	PART	H
D. Other Production	NE	-											PART	H	NO, NE	-	NO	-	PART	H
E. Production of Halocarbons and SF_6							PART	H	PART	H	PART	H								
F. Consumption of Halocarbons and SF_6																				
Potential [2]							PART	H	PART	H	PART	H								
Actual [3]							PART	H	PART	H	PART	H								
G. Other	NO	-	NO	-	NO	-	NO	-	NO	-	NO	-	NO	-	NO	-	NO	-	NO	-
3 Solvent and Other Product Use	**NO**	-			**ALL**	**H**							**NO**	-	**NO**	-	**PART**	**M**	**NO**	-
4 Agriculture	**NO**	-	**PART**	**L**	**PART**	**L**							**NE**	-	**PART**	**L**	**NE**	-	**NO**	-
A. Enteric Fermentation			ALL	M																
B. Manure Management			ALL	L	ALL	L											NE	-		
C. Rice Cultivation			ALL	L													NE	-		
D. Agricultural Soils	NO	-	NE	-	ALL	L											NE	-		
E. Prescribed Burning of Savannas			NO	-	NO	-							NO	-	NO	-	NO	-	NA	-
F. Field Burning of Agricultural Residues			PART	L	PART	L							NE	-	PART	L	NE	-	NA	-
G. Other			NO		NO	-							NO	-	NO	-	NO	-	NO	-
5 Land-Use Change and Forestry	**PART**	**M**	**PART**	**L**	**PART**	**L**							**PART**	**L**	**PART**	**L**	**NE**	-	**NE**	-
A. Changes in Forest and Other Woody Biomass Stocks	PART	M																		
B. Forest and Grassland Conversion	PART	M	PART	L	PART	L							PART	L	PART	L	NE	-		
C. Abandonment of Managed Lands	NE	-																		
D. CO2 Emissions and Removals from Soil	NE	-																		
E. Other	NO	-	NO	-	NO	-							NO	-	NO	-	NO	-	NO	-
6 Waste	**PART**	**H**	**PART**	**M**	**PART**	**L**							**PART**	**H**	**ALL**	**L**	**ALL**	**L**	**ALL**	**H**
A. Solid Waste Disposal on Land	IE	-	ALL	M											NO	-	NO	-		
B. Wastewater Handling			PART	M	NE	-							NE	-	NO	-	NO	-		
C. Waste Incineration	ALL	H	ALL	L	ALL	L							ALL	H	ALL	L	ALL	L	ALL	H
D. Other	NO	-	NO	-	NO	-							NO	-	NO	-	NO	-	NO	-
7 Other *(please specify)*	**NE**	-	**NE**	-	**NE**	-	**NE**	-	**NE**	-	**NE**	-	**NE**	-	**ALL**	**M**	**NE**	-	**NE**	-
International Bunkers	**ALL**	**H**	**ALL**	**L**	**PART**	**L**							**ALL**	**L**	**ALL**	**L**	**ALL**	**L**	**NE**	-

Table 2.2 Evaluation Criteria for Greenhouse Gas Source and Sink Categories, and Estimate Qualities

Estimate		Quality	
Codes	Meaning		Meaning
PART	Part of targets are estimated	**H**	a) Cases in which there are sufficient measured or documented values for emission factor, and it is clear that their variations (standard deviation, mean value) are 30 percent or less. b) Cases in which it is theoretically clear that the variable range of the emission factor is small. c) Cases in which, despite individual differences in emission factors, the actual emission amounts are ascertained through continuous data from statistics, survey reports, etc. based on actual measurements of the majority of emission sources.
ALL	All targets are estimated		
NE	Not estimated		
IE	Included in other sections	**M**	Cases other than H and L
NO	Not occuring	**L**	a) Cases in which it is either theoretically impossible to estimate the value of the emission factor and their variations, or where there are no or only singular values for survey/document data for emission factors applicable to Japan. b) Cases in which even though there are a number of survey/document data for emission factors, the factors differ by three times or more. c) Cases in which even though there are a number of survey/document data for emission factors and the factors differ by less than three times, it is estimated that the margin of error exceeds three times for the emission amount finally acquired.
NA	Not applicable (theoretically never possible)		

2.2 Carbon Dioxide (CO_2)

2.2.1 Outline of Emissions and Removals

Carbon dioxide (CO_2) is the most plentiful greenhouse gas in Japan in terms of both emissions and removals and is therefore a top policy priority. As shown in Table 2.3, carbon dioxide is considered in the following emission and removal sectors: Energy (1); Industrial Processes (2); Land-Use Change & Forestry (5); and Waste (6). Table 2.3 indicates that emissions total more than 1 billion tons (full molecular weight basis, here and below) per year.

Table 2.3 shows that carbon dioxide emissions for fiscal years 1990 through 1999 have risen every year except for 1993, 1997, and 1998. Increases in the Other Sectors (1A4) and Manufacturing Industries and Construction (1A2) subsectors of the Fuel Combustion Activities (1A) sector are small, but the increase observed in the Transport (1A3) subsector is notable. A decrease occurred in the Industrial Processes (2) sector. On the other hand, an increase occurred in the Waste (6) sector.

Calculations for emission and removal amounts in the Land-Use Change & Forestry (5) sector from fiscal 1990 to 1995 were based on default methods established in the IPCC Guidelines. No estimates were made for fiscal 1996 or later as activity cannot be calculated due to statistical limitations. Calculation methods

used in this sector are expected to change as greater understanding is acquired, however, total removals account for slightly less than 10% of total emissions.

In Table 2.4, in Fuel Combustion Activities (1A), emissions from electric power generation under the Energy Industries (1A1) are reallocated to subsectors (1A2 - 1A4) in accordance with electricity consumption. These values can be said to reflect the actual conditions and changes occurring in carbon dioxide emissions in these respective end-user sectors.

Figure 2.1 shows a breakdown of emissions by sector (fiscal 1999). The Fuel Combustion Activities (1A) sector is further broken down into subsectors. The subsector with the highest emissions is Energy Industries (1A1), which accounts for about 30% of the total. This is followed by Manufacturing Industries and Construction (1A2), Transport (1A3), and Other Sectors (1A4) in descending order. The Industrial Processes (2) sector, which primarily uses limestone, accounts for 4% of the total, and the Waste (6) sector, which primarily focuses on the burning of waste derived from fossil fuels, accounts for 2%. The bottom of Figure 2.1 shows emissions from electric power generation distributed to the end-user sectors that ultimately use the generated electricity. The Manufacturing Industries and Construction (1A2) subsector emits the most, followed in descending order by Other Sectors (1A4) and Transport (1A3).

Figures 2.2 and 2.3 show changes in emission amounts in each sector from fiscal 1990 through fiscal 1999. With the exception of fiscal 1993, 1997, and 1998, when an unusually cool summer and economic depression resulted in reduced emissions, emission levels rose consistently from 1990.

Emission amounts per sector from fiscal 1990 in descending order are 'Transport (1A3)' (49 million tons [23.9%] increase), 'Energy Industries (1A1)', (32.53 million tons [9.6%] increase), and 'Manufacturing Industries and Construction (1A2)' (18.71 million tons [5.5%] increase).

CO_2 emissions in the transportation sector (1A3) from fiscal 1990 to 1995 showed a significant increase of 17% compared to fiscal 1990 levels due to the increased number of vehicles, increased amount of driving in private passenger vehicles, standard modification of mini-cars to improve safety, and the increased size (weight) of vehicles reflecting user preferences change. However, since fiscal 1995, such movement has been flat in fiscal 1999 except for CO_2 emissions from private passenger vehicles, which had increased by 11% compared to fiscal 1995. The increase rate across the entire transportation sector has fallen off with CO_2 emissions for fiscal 1999 showing an increase of just 5.6% over fiscal 1995.

As for Energy Industries (1A1) (energy conversion sector), the increase in carbon dioxide emissions from electric utilities, which are the largest at about 85% of total emissions, was 22.59 million tons [7.7%] compared to fiscal 1990. The main reason for that may be the increase in electrical energy output in fiscal 1990 (about 22%) on the increase in demand of residential and commercial sectors, and so on. However, It was controlled that the CO2 emissions increased 7.7% in the same period, by the decline of CO2 intensity in electric generation due to the expansion of nuclear share, and so on.

On the other hand, only the Industrial Processes (2) sector shows a decrease from fiscal 1990 (5.56 million ton [9.5%] decrease compared to fiscal 1990). The amounts of carbon dioxide emitted from all emission

sources[1] of the 'Industrial Processes (2)' have declined. Reduction in carbon dioxide emissions from cement production is the largest – a 3.63 million ton [9.4%] decrease compared to fiscal 1990. Reduction in cement production by 7.4% compared to 1990 is likely to be main reason for that.

Emission figures for international bunkers have been separated as shown at the bottom of Table 2.3. This continues the practice adopted in the Second National Communication and is consistent with the Communication Guidelines. The amount of carbon dioxide emissions in fiscal 1999 increased by 5.32 million tons [17.4%] compared to fiscal 1990. Most of this increase has been caused by an increase in emissions from aircraft (5.34 million tons).

2.2.2 Methods of Estimating Emissions and Removals

Energy (1): Figures for the Fuel Combustion Activities (1A) sector were calculated by multiplying the total primary energy supply of each fuel [3)] by carbon dioxide emission factors [4)]. This is called the 'supply-based top-down calculating method'. Figures for all other sectors were derived by multiplying the amounts of each type of fuel consumed in each sector [3)] by their respective carbon dioxide emission factors [4)]. This is called the 'consumption-based top-down calculating method'. These two methods generate statistical errors that are allocated to the Other (1A5) subsector. Items that could not be classified into specific subsectors were also included in the Other (1A5) subsector.

Five percent of the carbons in 'coking coal' and 'petroleum coke' and 80% of the carbons in 'naphtha', 'lubricating oil', 'other petroleum products (asphalt, etc.)', and 'LPG' were assumed to be fixed in products. Carbon dioxide emissions from 'naphtha', 'LPG', 'natural gas', 'LNG', 'coal', and 'petroleum coke' for use in ammonia production are allocated to the Industrial Processes (2) sector.

Emissions from auto producers (power generated for their own use) were allocated not to the Energy Industries (1A1) subsector but rather divided among all relevant sectors according to how much electricity each sector produced and consumed. This approach is consistent with the Revised 1996 IPPC Guidelines. However, these figures do not reflect the different fuel mixes of each sector. Instead, the amount of carbon dioxide emitted per unit of electricity generated was calculated by using an average emission factor.

Industrial Processes (2): Carbon dioxide generated through thermal decomposition of limestone and other materials was calculated by multiplying the amounts of material consumed [5) 6)] by their respective emission factors. Similarly, the amounts of materials used to make ammonia [7)] were multiplied by the emission factors [4)].

[1] Emissions of carbon dioxide in line with production of cement, quicklime, soda lime and steel.

Land-Use Change & Forestry (5): Calculations were made for carbon removal amounts in forests, parks, and green land in accordance with the methods prescribed in the IPCC Guidelines. Necessary data concerning cut timber volumes, forested area, and amount of new growth were taken from the 'Statistical Handbook of Forestry' [8]. In terms of parks and green land, etc., Ministry of Land, Infrastructure and Transport survey data on parks and green land were used, as well as IPCC default values for new growth amounts. 'Not estimated' was recorded for some activity data that cannot be obtained due to statistical limitations for fiscal 1996 onwards.

Waste (6): Calculations were also made for Waste Incineration (6C). For municipal solid waste, the amount of waste burned was multiplied by the percentage of waste derived from fossil fuels [9], with the result further multiplied by the emission factors. For industrial waste, emission amounts were calculated by multiplying the amounts of incinerated waste oil and waste plastic [10] by the emission factors.

The same inventory calculation methods as used in the Second National Communication were adopted this time.

Table 2.3 Carbon Dioxide Emission and Removals (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total National Emissions	1,124,350	1,147,789	1,162,218	1,143,968	1,214,078	1,217,764	1,236,191	1,233,525	1,186,964	1,224,980
Total Removals	-83,882	-83,843	-85,541	-90,057	-93,516	-96,676	NE	NE	NE	NE
1 Energy	1,052,782	1,072,706	1,085,118	1,064,565	1,133,429	1,138,556	1,153,570	1,150,775	1,109,504	1,147,945
1A Fuel Combustion Activities	1,052,782	1,072,706	1,085,118	1,064,565	1,133,429	1,138,556	1,153,570	1,150,775	1,109,504	1,147,945
1A1. Energy Industries	338,908	341,967	349,458	331,667	369,322	359,370	360,447	356,859	349,661	371,437
1A2. Manufacturing Industries and Construction	339,227	337,590	327,780	332,138	340,622	345,719	352,685	353,503	343,015	357,939
1A3. Transport	204,665	214,152	219,398	221,689	232,679	239,522	246,016	250,350	250,286	253,670
1A4. Other Sectors	158,233	164,502	169,778	168,984	167,049	177,029	173,326	171,614	167,056	165,624
1A5. Other	11,749	14,494	18,704	10,086	23,757	16,916	21,095	18,448	-513	-726
1B Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2. Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 Industrial Processes	58,795	60,382	60,999	60,333	61,303	61,237	61,079	59,501	53,956	53,233
3 Solvent and Other Product Use	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4 Agriculture	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4A Enteric Fermentation										
4B Manure Management										
4C Rice Cultivation										
4D Agricultural Soils	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4E Prescribed Burning of Savannas										
4F Field Burning of Agricultural Residues										
4G Other										
5 Land-Use Change and Forestry	-83,882	-83,843	-85,541	-90,057	-93,516	-96,676	NE	NE	NE	NE
5A Changes in Forest and Other Woody Biomass Stocks	-84,461	-84,751	-86,456	-90,979	-94,445	-97,618	NE	NE	NE	NE
5B Forest and Grassland Conversion	579	908	915	922	929	942	NE	NE	NE	NE
5C Abandonment of Managed Lands	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO	NE, NO
5D CO2 Emissions and Removals from Soil	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6 Waste	12,773	14,701	16,101	19,070	19,346	17,971	21,541	23,249	23,504	23,802
6A Solid Waste Disposal on Land	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
6B Wastewater Handling										
6C Waste Incineration	12,773	14,701	16,101	19,070	19,346	17,971	21,541	23,249	23,504	23,802
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International Bunkers	30,525	32,724	33,770	36,322	37,123	36,989	32,181	36,344	36,686	35,841

Note: If there are two notation keys in subsectors, the both (i.e. NE and NO) are shown.

Table 2.4 Carbon Dioxide Emissions (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1A Fuel Combustion Activities	1,052,782	1,072,706	1,085,118	1,064,565	1,133,429	1,138,556	1,153,570	1,150,775	1,109,504	1,147,945
1A1. Energy Industries	77,307	78,555	79,604	78,880	82,790	82,845	81,698	83,443	83,797	86,350
1A2. Manufacturing Industries and Construction	455,422	452,708	441,904	435,922	454,792	454,577	462,303	460,407	442,080	463,387
1A3. Transport	211,386	220,907	226,244	228,197	239,646	246,241	252,619	256,689	256,386	259,911
1A4. Other Sectors	297,280	306,582	318,984	311,812	332,559	338,526	336,379	332,016	327,878	339,090
1A5. Other	11,387	13,953	18,382	9,753	23,642	16,367	20,571	18,221	-637	-792

Note: In ‘Fuel Combustion Activities (1A)’, emissions from electric power generation under the ‘Energy Industries (1A1)’ subsector are reallocated to subsectors (1A2 – 1A4) in accordance with electricity consumption.

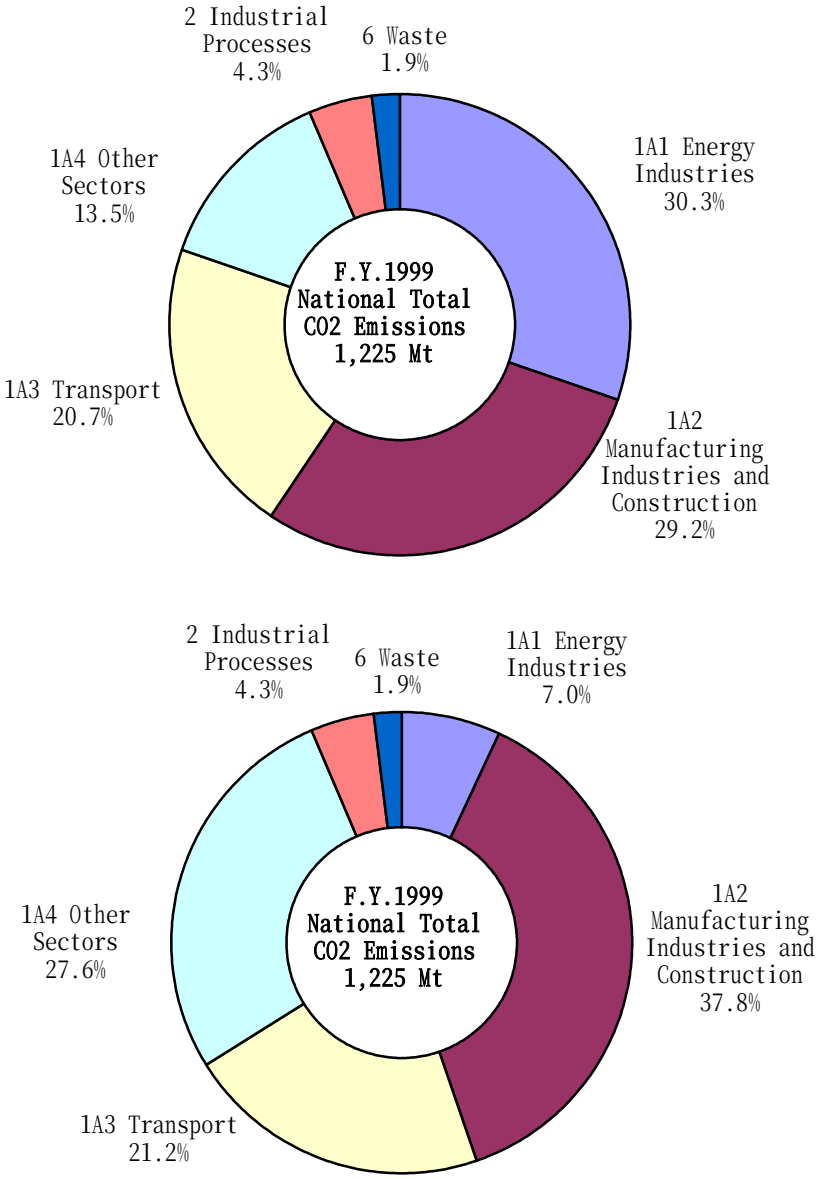

Figure 2.1 Breakdown of Carbon Dioxide Emissions

Note: The lower graph shows the breakdown in which emissions from electric power generation under the 'Energy Industries (1A1)' are reallocated to subsectors (1A2 – 1A4) in accordance with electricity consumption.

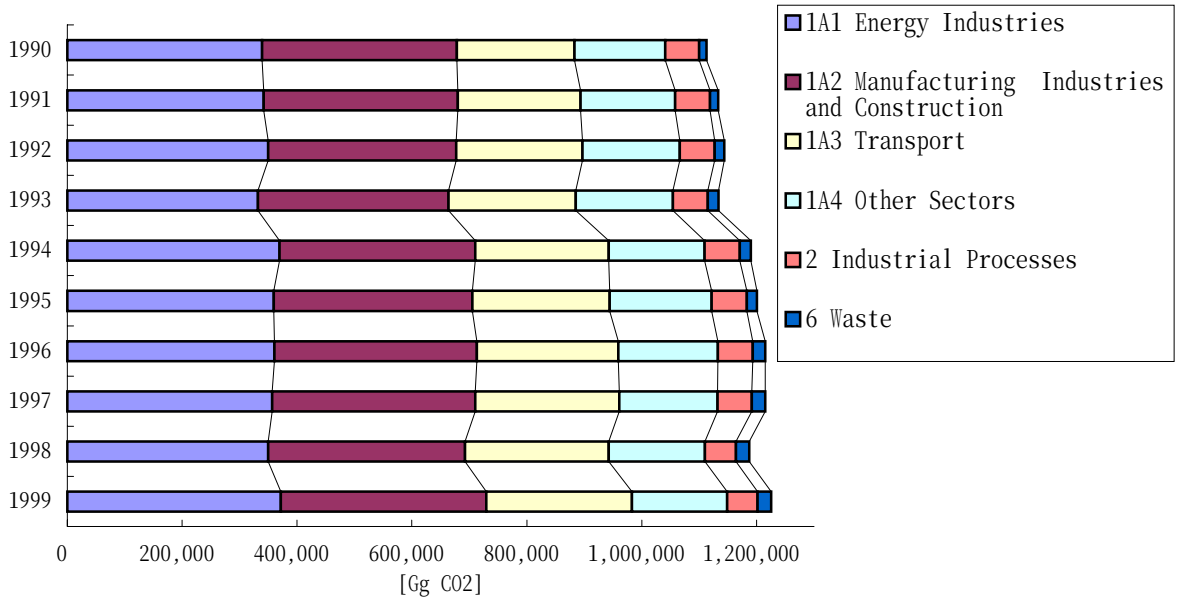

Figure 2.2 Breakdown of Carbon Dioxide Emissions by Sector (Fiscal 1990 – 1999)

Note: Emissions and removals from Land-Use Change & Forestry sector are not included.

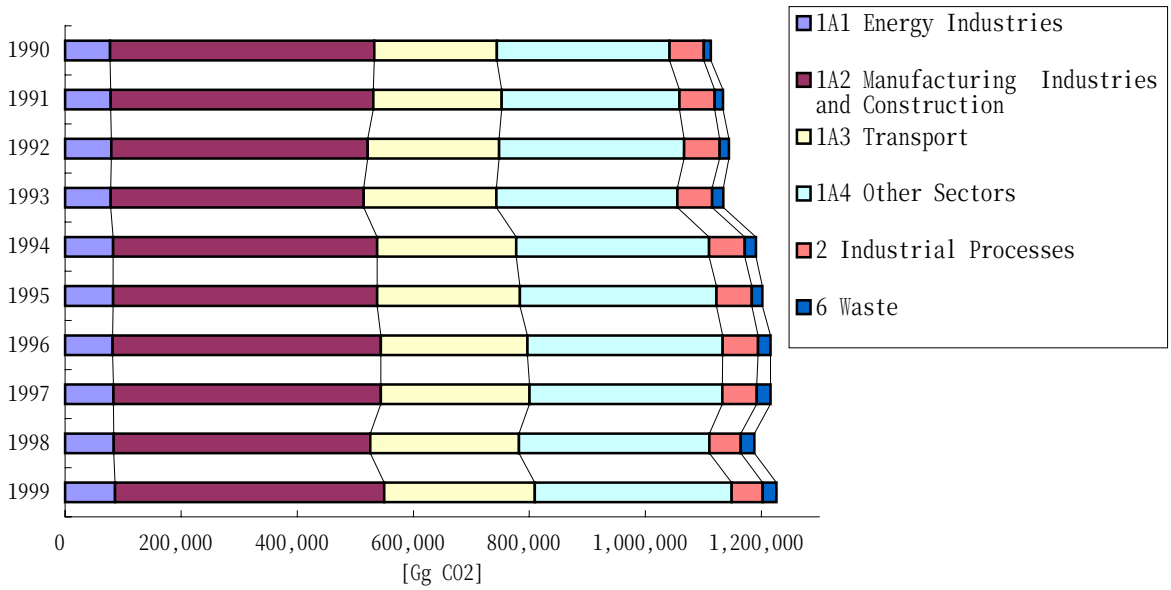

Figure 2.3 Breakdown of Carbon Dioxide Emissions by Sector (Fiscal 1990 – 1999)

Note: The breakdown in which emissions from electric power generation under the 'Energy Industries (1A1)' are reallocated to subsectors (1A2 – 1A4) in accordance with electricity consumption.
Emissions and removals from Land-Use Change & Forestry sector are not included.

2.3 Methane (CH_4)

2.3.1 Outline of Emissions

Japan emitted approximately 1.29 million tons of methane (actual weight) in fiscal 1999, primarily from activities in the Energy (1), Industrial Process (2), Agriculture (4), and Waste (6) sectors.

Table 2.5 shows changes in methane emissions in each sector from fiscal 1990. Total emissions have been reduced by 165,000 tons [11.4%] compared to fiscal 1990. From the view point of reduction amounts of emissions per emission source from fiscal 1990, Solid Fuels (1B1)is the most important sector, which has declined by 58,000 tons [54.2%] mainly reflecting the decline in the amount of domestic coal mined by 53.8% compared to fiscal 1990. Rice Cultivation (4C) has declined by 50,000 tons [13.4%], mainly due to a 13.4% reduction in productive paddy field area compared to fiscal 1990.

Fuel Combustion Activities/Transport (1A3) has declined by 31,000 tons [41.3%] compared to fiscal 1990, mainly reflecting a decline of 34.4% [11)] in emission factors of mini-sized cargo vehicles, which account for nearly 60% of emissions from concerned emission sources, since fiscal 1990.

On the other hand, emissions from Oil and Natural Gas (1B2) have increased by 31,000 tons [58.7%] since fiscal 1990. It is thought that the main reason is a 71.3% increase in natural gas consumption since fiscal 1990.

Figure 2.4 shows the breakdown of emissions by sector. The most important sector is Agriculture (4), which accounts for about 52.8% of the total. Within this sector, the main subsectors are Enteric Fermentation (4A), Manure Management (4B), and Rice Cultivation (4C). Under Energy (1), Fuel Combustion Activities (1A) and Fugitive Emissions from Fuels (1B) account for 4.5% and 10.3% of the total, respectively. Under Waste (6), the main subsector is Solid Waste Disposal on Land (6A), which accounts for 28.1% of the total.

2.3.2 Methods of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing Industries and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion Activities (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission factors [12)]. This is a “bottom-up” approach. The remainder of the Other Sectors (1A4) involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars). Emissions falling under the Solid Fuels (1B1) subsector of Fugitive Emissions from Fuels (1B) were calculated by multiplying the amount of coal mined [13)] by the methane emission factor. For the Oil and Natural Gas (1B2)

subsector, the amounts of each fuel produced and handled [3] were multiplied by the default emission factors of the Revised 1996 IPCC Guidelines.

Industrial Processes (2): The amounts of different chemical products manufactured were multiplied by their respective default emission factors from the Revised 1996 IPCC Guidelines.

Agriculture (4): For the Enteric Fermentation (4A) subsector, emissions were calculated by multiplying the numbers of each type of animal [14] by the emission factors. Emissions in the Manure Management (4B) subsector are calculated by using the method [15] that reflects the Japanese situation in this subsector. Methane emissions in the Rice Cultivation (4C) subsector were calculated by multiplying the areas of cultivated rice paddies [16] (broken down by soil type) by the appropriate emission factors.

Land-Use Change & Forestry (5): Consideration was given to the burning of biomass that accompanies the conversion of forest land to other uses, and calculations were made on the basis of default methods indicated in the Revised 1996 IPCC Guidelines.

Waste (6): For the Solid Waste Disposal on Land (6A) subsector, emissions were calculated using a model that gives consideration to the methane emission process as it occurs over the course of several years after the waste was buried in landfill [17]. For the Waste Incineration (6C) subsector, the amounts of waste processed in the Waste Incinerator designated by the Air Pollution Control Law was multiplied by the emission factors [12].

Table 2.5 Methane Emissions (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	1,452	1,443	1,435	1,428	1,414	1,404	1,375	1,318	1,298	1,287
1 Energy	249	245	241	232	220	221	220	189	186	190
1A Fuel Combustion Activities	89	81	74	66	59	60	59	59	57	58
1A1. Energy Industries	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
1A2. Manufacturing Industries and Construction	7	7	7	7	6	6	6	6	6	6
1A3. Transport	76	67	59	52	46	46	44	45	45	44
1A4. Other Sectors	9	8	9	9	9	10	9	9	9	9
1A5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B Fugitive Emissions from Fuels	160	165	167	166	161	160	162	130	129	132
1B1. Solid Fuels	107	107	107	101	94	89	87	53	50	49
1B2. Oil and Natural Gas	52	57	61	65	67	71	74	78	79	83
2 Industrial Processes	49	48	46	45	48	49	50	50	47	48
3 Solvent and Other Product Use										
4 Agriculture	758	763	768	776	771	756	736	713	697	681
4A Enteric Fermentation	345	350	351	348	344	339	335	331	328	324
4B Manure Management	35	35	35	34	33	33	32	32	31	31
4C Rice Cultivation	373	374	378	388	389	379	364	345	333	323
4D Agricultural Soils	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4E Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4F Field Burning of Agricultural Residues	5	5	5	6	5	6	5	5	4	4
4G Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 Land-Use Change and Forestry	3	4	4	4	4	4	NE	NE	NE	NE
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion	3	4	4	4	4	4	NE	NE	NE	NE
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	394	383	376	372	370	374	369	366	369	368
6A Solid Waste Disposal on Land	388	377	369	365	364	367	362	358	361	360
6B Wastewater Handling	6	6	6	7	6	6	7	7	8	7
6C Waste Incineration	0	0	0	0	0	0	0	0	0	0
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International Bunkers	2	2	2	2	3	2	2	2	2	2

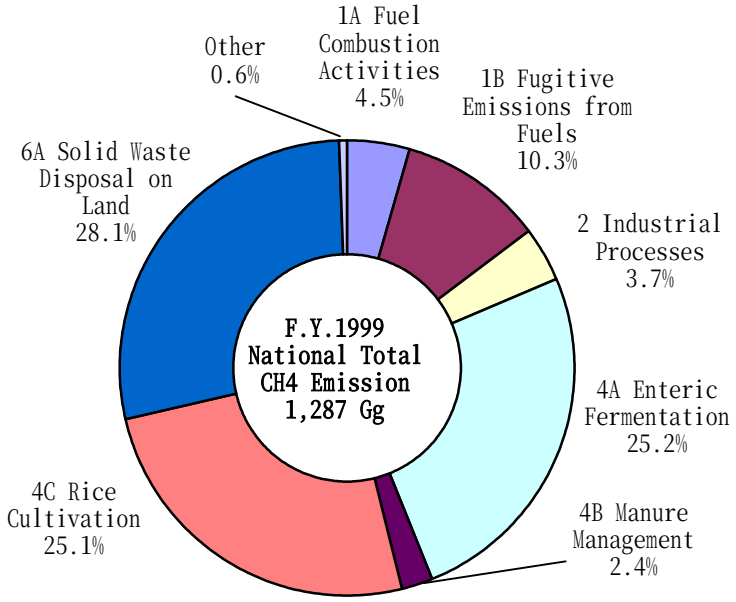

Figure 2.4 Breakdown of Methane Emissions (Fiscal 1999)

2.4 Nitrous Oxide (N_2O)

2.4.1 Outline of Emissions

Nitrous oxide (N_2O) emissions in fiscal 1999 in Japan totaled about 50,000 tons (actual weight of nitrous oxide).

Table 2.6 shows emissions in all sectors from fiscal 1990 through 1999. Total emissions increased until fiscal 1997, but significantly declined up to fiscal 1999. The significant reduction from fiscal 1998 to 1999 is mainly because of the introduction in March 1999 of a decomposition system for nitrous oxide emitted in the production of adipic acid and emissions from this emission source declined by 19,000 tons (88.1%) compared to fiscal 1990.

Figure 2.5 breaks down nitrous oxide emissions in fiscal 1999 according to sector. The Energy (1) sector accounted for 47.5% of all emissions, followed in descending order by Agriculture (4) [29.6%], Waste (6) [11.8%], and Industrial Processes (2) [8.9%].

2.4.2 Methods of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission

factors [12]. This is a "bottom-up" approach. The remainder of the Other Sectors (1A4) subsector involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars).

Industrial Processes (2): Emissions from the manufacture of adipic acid [18] and nitric acid [19] were calculated by multiplying the respective amounts manufactured by the emission factors.

Solvent and Other Product Use (3): The amount of nitrous oxide shipped as medical gas (laughing gas) [20] was considered equal to the amount of emissions.

Agriculture (4): For Manure Management (4B), emissions were calculated using the method reflecting Japanese circumstances [15]. For the Agricultural Soils (4D) subsector, emissions were calculated by multiplying the amount of nitrogen fertilizer [21] used (other than in rice paddies) by the emission factor [22].

Land-Use Change & Forestry (5): Consideration was given to the burning of biomass that accompanies the conversion of forest land to other uses, and calculations were made on the basis of default methods indicated in the revised 1996 IPCC Guidelines.

Waste (6): For the Waste Incineration (6C) subsector, the amount of waste processed in the Waste Incinerator designated by the Air Pollution Control Law was multiplied by the emission factors[12]. The emission from sewage sludge was estimated, taking account of incinerator type, etc. [23].

Table 2.6 Nitrous Oxide Emissions (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	67.0	65.4	65.8	65.3	69.2	70.3	73.6	75.9	72.0	53.3
1 Energy	19.3	20.2	20.7	20.9	21.9	23.6	24.0	24.7	24.5	25.3
1A Fuel Combustion Activities	19.3	20.2	20.7	20.9	21.9	23.6	24.0	24.7	24.5	25.3
1A1. Energy Industries	2.1	2.2	2.3	2.4	2.6	3.8	3.8	3.9	3.8	4.1
1A2. Manufacturing Industries and Construction	4.0	4.3	4.3	4.5	5.1	5.2	5.4	5.8	5.7	6.0
1A3. Transport	12.9	13.4	13.7	13.7	13.9	14.3	14.5	14.7	14.6	14.9
1A4. Other Sectors	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
1A5. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B Fugitive Emissions from Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B1. Solid Fuels	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
1B2. Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 Industrial Processes	23.9	21.9	21.6	21.2	24.0	23.8	26.6	28.1	24.5	4.7
3 Solvent and Other Product Use	0.9	1.2	1.3	1.3	1.4	1.4	1.4	1.3	1.2	1.2
4 Agriculture	18.0	17.6	17.5	17.3	16.9	16.4	16.1	16.0	15.9	15.8
4A Enteric Fermentation										
4B Manure Management	13.5	13.3	13.2	12.9	12.6	12.4	12.2	12.1	12.0	11.9
4C Rice Cultivation										
4D Agricultural Soils	3.8	3.6	3.6	3.5	3.5	3.3	3.1	3.1	3.1	3.1
4E Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4F Field Burning of Agricultural Residues	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7
4G Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 Land-Use Change and Forestry	0.0	0.0	0.0	0.0	0.0	0.0	NE	NE	NE	NE
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion	0.0	0.0	0.0	0.0	0.0	0.0	NE	NE	NE	NE
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	4.9	4.6	4.6	4.6	4.9	5.1	5.5	5.8	6.0	6.3
6A Solid Waste Disposal on Land										
6B Wastewater Handling	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6C Waste Incineration	4.9	4.6	4.6	4.6	4.9	5.1	5.5	5.8	6.0	6.3
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other										
International Bunkers	0.5	0.5	0.5	0.6	0.6	0.5	0.4	0.5	0.5	0.5

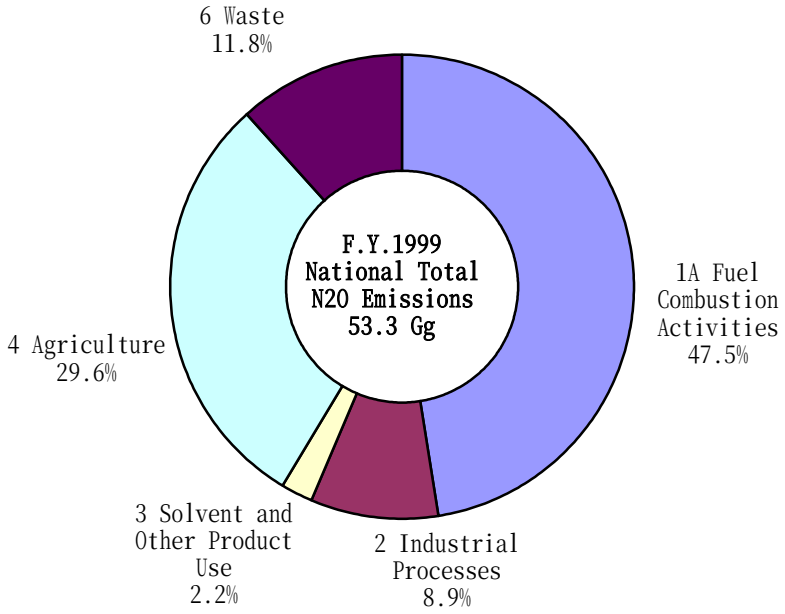

Figure 2.5 Breakdown of Nitrous Oxide Emissions (Fiscal 1999)

2.5 Hydrofluorocarbons (HFCs)

2.5.1 Outline of Emissions

Hydrofluorocarbons (HFCs) have been used in refrigerants, aerosols, and other goods in recent years. The amount of HFC emissions in Japan was about 19.5 million tons of carbon dioxide equivalents in fiscal 1999, with a potential emissions amount of about 38.72 million tons of carbon dioxide equivalents.

Table 2.7 outlines the HFCs emissions since fiscal 1995. From fiscal 1995 to 1999, the emission amount has declined. A reduction in HFC production is the main reason behind that.

Figure 2.6 shows a breakdown of HFCs emissions in each sector in fiscal 1999. The main sectors, in descending order, are by-products during HCFC-22 production (72.3%), aerosols, MDI (metered-dose inhaler) (14.3%), refrigerators and air conditioners (9.7%), and foaming agents (2.1%).

2.5.2 Methods of Estimating Emissions

Emission amounts at each stage from production to disposal were estimated using industry statistics in business circles and suchlike.

Table 2.7 Actual Emissions of Hydrofluorocarbons (Fiscal 1995 – 1999)

	unit	1995	1996	1997	1998	1999
Total Actual Emissions	[Gg CO2eq.]	20,044	19,662	19,584	19,027	19,497
E.Production of Halocarbons and SF6	[Gg CO2eq.]	17,398	16,007	15,032	13,995	14,203
1.By-product Emissions (HCFC-22)	[Gg CO2eq.]	16,965	15,596	14,695	13,783	14,102
2.Fugitive Emissions	[Gg CO2eq.]	433	411	337	212	101
F(a).Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	[Gg CO2eq.]	2,646	3,655	4,552	5,032	5,294
1.Refrigeration and Air Conditioning Equipment	[Gg CO2eq.]	706	1,025	1,311	1,657	1,889
2.Foam Blowing	[Gg CO2eq.]	455	415	412	406	403
3.Fire Extinguishers	[Gg CO2eq.]	IE	IE	IE	IE	IE
4.Aerosols/Metered Dose Inhalers	[Gg CO2eq.]	1,365	2,084	2,646	2,795	2,792
6.Semiconductor Manufacture	[Gg CO2eq.]	120	113	150	139	144
8.Other	[Gg CO2eq.]	1	18	33	35	66

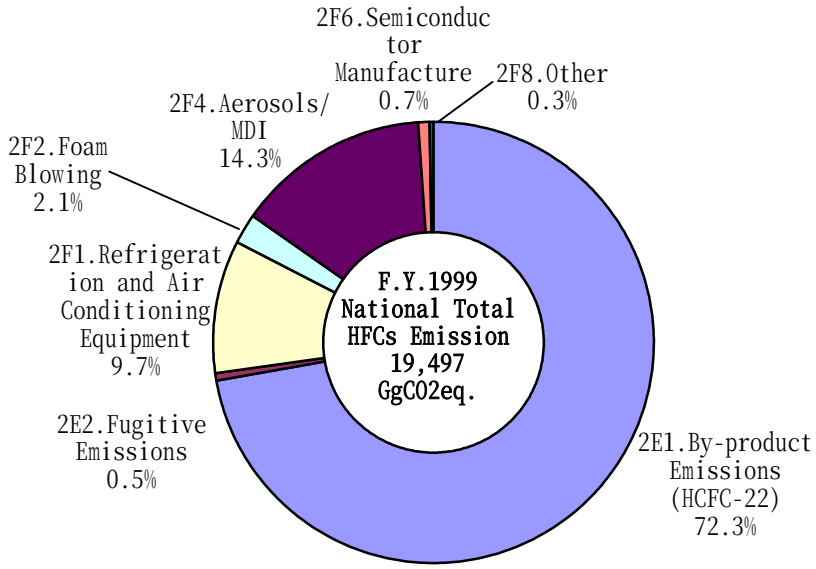

Figure 2.6 Breakdown of Hydrofluorocarbons Emissions (Fiscal 1999)

Table 2.8 Potential Hydrofluorocarbon Emissions (Fiscal 1990 – 1999)

	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
F(p). Total Potential Emissions	[Gg CO2eq.]	17,930	18,070	19,750	21,310	28,840	31,160	31,628	34,890	31,554	38,722
HFC-23 (CHF3、GWP=11700)	[t]	1,500	1,500	1,500	1,300	1,500	1,500	1,459	1,555	1,547	1,544
Prodction	[t]	1,500	1,500	1,500	1,300	1,500	1,500	1,459	1,555	1,547	1,544
Import	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Export	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Destroyed Amount	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
HFC-134a (C2H2F4、GWP=1300)	[t]	0	400	1,400	4,400	8,100	9,300	9,886	11,674	9,615	14,153
Prodction	[t]	0	200	2,500	11,100	18,400	22,000	24,949	23,728	20,502	25,693
Import	[t]	0	200	300	200	0	0	0	846	310	0
Export	[t]	0	0	1,400	6,900	10,300	12,700	15,063	12,900	11,197	11,540
Destroyed Amount	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Other HFCs※	[Gg CO2eq.]	380	0	380	380	760	1,520	1,706	1,520	954	2,258
Prodction	[Gg CO2eq.]	0	0	0	380	760	1,140	1,398	1,140	977	1,538
Import	[Gg CO2eq.]	380	0	380	0	0	380	308	380	649	1,770
Export	[Gg CO2eq.]	0	0	0	0	0	0	0	0	671	1,049
Destroyed Amount	[Gg CO2eq.]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

*) Other HFCs include HFC-32 (CH2F2, GWP: 650), HFC-125 (C2HF5, GWP: 2800), HFC-152a (C2H4F2, GWP: 140), and HFC-143a (C2H3F3, GWP: 3800). 3800 is adopted as GWP of other HFCs as a breakdown of such HFCs between 1990 and 1997 cannot be clearly specified.

2.6 Perfluorocarbons (PFCs)

2.6.1 Outline of Emissions

Perfluorocarbons (PFCs) are used as semiconductor etching gases and cleaning solvents for electronic parts. The PFC emissions amount in Japan was about 11.04 million tons of carbon dioxide equivalents in fiscal 1999, with a potential emissions amount of about 17.4 million tons of carbon dioxide equivalents.

Table 2.9 outlines PFC emissions since fiscal 1995. From fiscal 1995 to 1999, the emission amount has declined. Reduction in emissions amount in the sector of cleaning solvents of electronic parts and so on is the main reason for that.

Figure 2.7 shows a breakdown of PFC emissions in each sector in fiscal 1999. The main sectors are solvents (45.9%), semiconductor production (42.6%), and fugitive emissions (11.5%) in descending order.

2.6.2 Methods of Estimating Emissions

Emission amounts at each stage of production to disposal were estimated using the industry statistics in business circles and suchlike.

Table 2.9 Actual Emissions of Perfluorocarbons (Fiscal 1995 – 1999)

	unit	1995	1996	1997	1998	1999
Total Actual Emissions	[Gg CO2eq.]	11,433	11,201	13,953	12,390	11,043
E.Production of Halocarbons and SF6	[Gg CO2eq.]	762	1,008	1,417	1,390	1,273
2.Fugitive Emissions	[Gg CO2eq.]	762	1,008	1,417	1,390	1,273
F(a).Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	[Gg CO2eq.]	10,671	10,193	12,536	11,000	9,770
5.Solvents	[Gg CO2eq.]	7,014	6,729	8,207	6,671	5,068
6.Semiconductor Manufacture	[Gg CO2eq.]	3,658	3,465	4,329	4,329	4,702

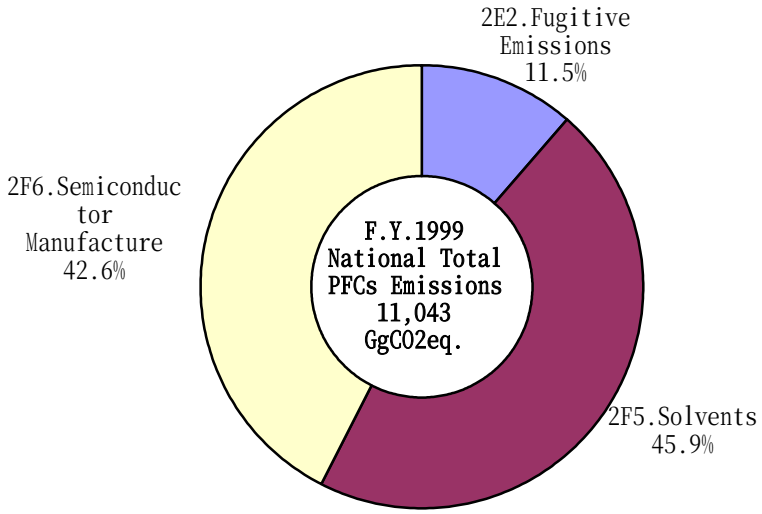

Figure 2.7 Breakdown of Actual Perfluorocarbon Emissions (Fiscal 1999)

Table 2.10 Potential Perfluorocarbon Emissions (Fiscal 1990 – 1999)

	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
F(p). Total Potential Emissions	[Gg CO2eq.]	5,670	6,370	6,370	8,860	12,274	16,601	18,622	19,650	17,786	17,397
PFC-14 (CF4, GWP=6500)	[t]	300	300	300	360	500	650	740	700	198	417
Prodction	[t]	400	400	400	460	600	750	840	800	908	860
Import	[t]	0	0	0	0	0	0	0	0	0	0
Export	[t]	100	100	100	100	100	100	100	100	710	443
Destroyed Amount	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Other PFCs※	[Gg CO2eq.]	3,720	4,420	4,420	6,520	9,024	12,376	13,812	15,100	16,499	14,686
Prodction	[Gg CO2eq.]	920	920	920	920	1,380	3,276	5,080	6,000	7,935	8,941
Import	[Gg CO2eq.]	2,800	3,500	3,500	5,600	7,644	10,020	10,812	11,640	11,409	8,011
Export	[Gg CO2eq.]	0	0	0	0	0	920	2,080	2,540	2,846	2,266
Destroyed Amount	[Gg CO2eq.]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

*) Other PFCs include PFC-116 (C_2F_6, GWP: 9200), PFC-218 (C_3F_8, GWP: 7000), PFC-c318 (c-C_4F_8, GWP: 8700), and PFC-41-12 (C_5F_{12}, GWP: 7500). 7000 is adopted as GWP of other PFCs as breakdown of such PFCs between 1990 and 1997 cannot be clearly specified.

2.7 Sulfur Hexafluoride (SF_6)

2.7.1 Outline of Emissions

Sulfur hexafluoride (SF_6) has been used as an electric power insulation gas. It has also been used in recent years as a semiconductor etching gas. The actual SF_6 emission amount in Japan was about 8.35 million tons of carbon dioxide equivalents in fiscal 1999, with a potential emission amount of about 34.06 million tons of carbon dioxide equivalents.

Figure 2.8 shows a breakdown of SF_6 emissions in each sector in fiscal 1999. The main sectors are electrical equipment (59.5%), semiconductor production (22.2%), and fugitive emissions (18.3%) in descending order.

2.7.2 Methods of Estimating Emissions

Emission amount at each stage of production to disposal were estimated using industry statistics in business circles and suchlike.

Table 2.11 Actual Emissions of Sulfur Hexafluoride (Fiscal 1995 – 1999)

	unit	1995	1996	1997	1998	1999
Total Actual Emissions	[Gg CO2eq.]	16,730	17,181	14,435	12,824	8,351
E.Production of Halocarbons and SF6	[Gg CO2eq.]	4,708	4,183	2,581	2,103	1,527
2.Fugitive Emissions	[t]	197	175	108	88	64
F(a).Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	[Gg CO2eq.]	12,022	12,998	11,854	10,721	6,824
6.Semiconductor Manufacture	[t]	43	51	65	68	77
7.Electrical Equipment	[t]	460	493	431	380	208

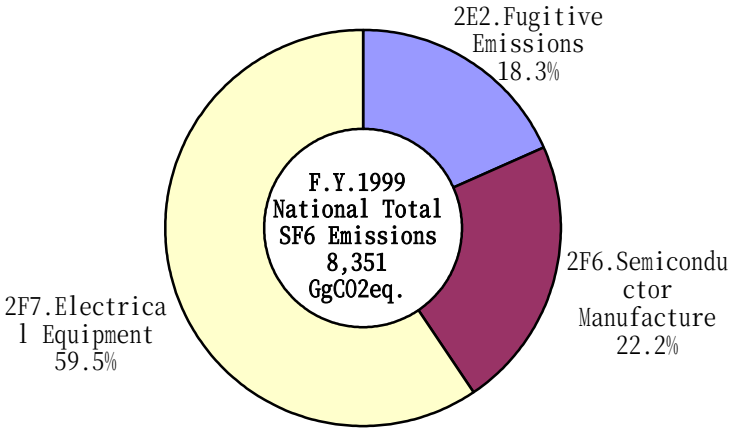

Figure 2.8 Breakdown of Actual Sulfur Hexafluoride Emissions (Fiscal 1999)

Table 2.12 Potential Sulfur Hexafluoride Emissions (Fiscal 1990 – 1999)

	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
F(p). Total Potential Emissions	[Gg CO2eq.]	38,240	43,498	47,800	45,410	45,410	52,580	50,190	49,712	49,999	34,058
SF6 (GWP=23900)	[t]	1,600	1,820	2,000	1,900	1,900	2,200	2,100	2,080	2,092	1,425
Prodction	[t]	1,900	2,060	2,300	2,200	2,200	2,400	2,400	2,540	2,440	1,838
Import	[t]	0	80	0	0	0	0	0	0	0	0
Export	[t]	300	320	300	300	300	200	300	460	348	413
Destroyed Amount	[t]	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

2.8 Nitrogen Oxide (NO_x)

2.8.1 Outline of Emissions

Japan emitted approximately 2 million tons of nitrogen oxides (NO_x) in fiscal 1999, primarily from activities in the Energy (1), Industrial Processes (2), and Waste (6) sectors. NO_x emissions are calculated as NO_2 equivalent weights.

Table 2.13 shows emissions from fiscal 1990 through fiscal 1999. Although there have been fluctuations, the overall amount of emissions has remained essentially stable. Increases have occurred in the following sectors: Fuel Combustion Activities (1A) excluding the Energy Industry (1A1) subsector and Waste Incineration (6C). These rises reflect increases in fuel consumption and greater amounts of incinerated waste.

Figure 2.9 breaks down nitrogen oxide emissions in fiscal 1999 according to sector. The Fuel Combustion Activities (1A) sector accounted for 93% of all emissions, broken down in descending order into the following subsectors: Transport (1A3), Manufacturing Industries and Construction (1A2), Energy Industries (1A1), and Other Sectors (1A4). The Industrial Processes (2) sector accounted for 4.2% of the total, and the Waste (6) sector accounted for 3.3%.

2.8.2 Method of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing Industries and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion Activities (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission factors [12]. This is a "bottom-up" approach. The remainder of the Other Sectors (1A4) subsector involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars). Emissions for motor vehicles were calculated by determining the total distance traveled by each type of vehicle and multiplying by the emission factors [24]. In all others, the default emission factors of the Revised 1996 IPCC Guidelines were used.

Industrial Processes (2): Estimates were made for nitrogen oxide emissions from soot and smoke-emitting facilities designated by the Air Pollution Control Law [12].

Land-Use Change & Forestry (5): Consideration was given to the burning of biomass that accompanies the

conversion of forest land to other uses, and calculations were made on the basis of default methods indicated in the Revised 1996 IPCC Guidelines.

Waste (6): For the Waste Incineration (6C) subsector, the amounts of waste processed in Waste Incinerators designated by the Air Pollution Control Law were multiplied by the emission factors [12].

Table 2.13 Nitrogen Oxide Emissions (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	1,867.2	1,910.4	1,896.1	1,887.1	1,917.7	2,007.7	2,017.4	2,047.3	1,964.7	1,996.0
1 Energy	1,722.4	1,751.6	1,742.8	1,737.2	1,766.0	1,854.4	1,867.7	1,894.3	1,815.6	1,847.7
1A Fuel Combustion Activities	1,722.4	1,751.6	1,742.8	1,737.2	1,766.0	1,854.4	1,867.7	1,894.3	1,815.6	1,847.7
1A1. Energy Industries	265.4	267.5	264.6	253.4	264.4	251.4	246.9	243.5	236.9	251.0
1A2. Manufacturing Industries and Construction	451.8	438.7	433.2	450.5	467.8	508.9	499.7	504.8	483.1	494.0
1A3. Transport	915.9	959.2	951.1	926.6	931.9	963.3	993.7	1,020.2	973.2	979.5
1A4. Other Sectors	89.2	86.2	93.9	106.7	101.9	130.8	127.4	125.9	122.5	123.2
1A5. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1B Fugitive Emissions from Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2. Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 Industrial Processes	92.2	102.5	96.8	92.4	91.9	90.6	88.3	90.3	84.1	83.3
3 Solvent and Other Product Use										
4 Agriculture	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4A Enteric Fermentation										
4B Manure Management										
4C Rice Cultivation										
4D Agricultural Soils										
4E Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4F Field Burning of Agricultural Residues	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4G Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 Land-Use Change and Forestry	0.6	1.0	1.0	1.0	1.0	1.0	NE	NE	NE	NE
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion	0.6	1.0	1.0	1.0	1.0	1.0	NE	NE	NE	NE
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	52.1	55.3	55.4	56.6	58.8	61.6	61.4	62.8	64.9	64.9
6A Solid Waste Disposal on Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6B Wastewater Handling	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
6C Waste Incineration	52.1	55.3	55.4	56.6	58.8	61.6	61.4	62.8	64.9	64.9
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International Bunkers	475.5	515.4	535.5	595.2	601.2	558.6	415.1	497.2	521.4	496.6

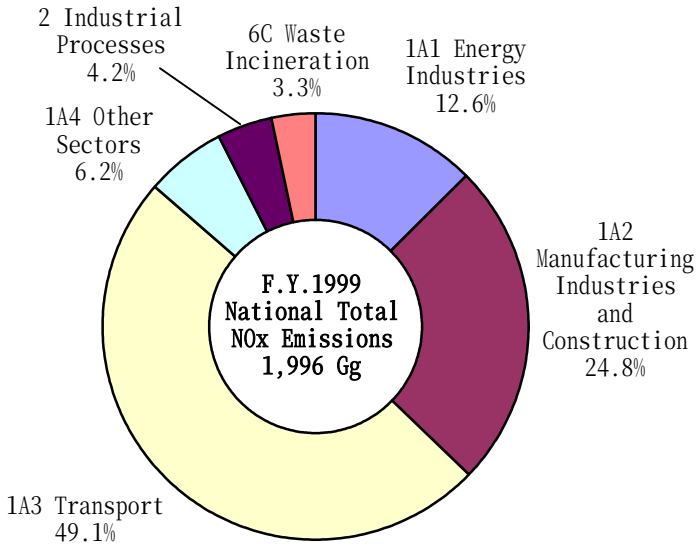

Figure 2.9 Breakdown of Nitrogen Oxide Emissions (Fiscal 1999)

2.9 Carbon Monoxide (CO)

2.9.1 Outline of Emissions

Japan emitted approximately 3.67 million tons of carbon monoxide (CO) in fiscal 1999, almost all of which came from the Fuel Combustion Activities (1A) sector.

Table 2.14 shows emissions from fiscal 1990 through fiscal 1999. The overall amount of emissions has declined slightly. About 55% is emitted from the Transport (1A3) sector, of which 97% is generated by motor vehicles. Increases have been observed in the Waste Incineration (6C) subsector. Declines have occurred in the following subsectors: Energy Industries (1A1) and Manufacturing Industries and Construction (1A2).

Figure 2.10 breaks down carbon monoxide emissions in fiscal 1999 according to sector. The Fuel Combustion Activities (1A) sector under Energy (1) accounted for about 95% of all emissions, broken down in descending order into the following subsectors: Transport (1A3), Manufacturing Industries and Construction (1A2), Energy Industries (1A1), and Other Sectors (1A4). Nearly all of the emissions in the Transport (1A3) sector were from motor vehicles (1.95 million tons as of fiscal 1999, which accounted for 53% of total emissions). The emissions amount from Burning of Agricultural Residues (4F) is considered for Agriculture (4), which accounted for 3.7% of total emissions. The Waste (6) sector accounted for 1.1% of total emissions, taking into account emissions generated in the Waste Incineration (6C) subsector.

2.9.2 Methods of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing Industries and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion Activities (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission factors [12]. This is a "bottom-up" approach. The remainder of the Other Sectors (1A4) subsector involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars). Emissions for automotive vehicles were calculated by determining the total distance traveled by each type of vehicle and multiplying by the emission factors [24]. In all others, the default emission factors from the Revised 1996 IPCC Guidelines were used.

Agriculture (4): Carbon monoxide emissions generated in the Field Burning of Agricultural Residues (4F) subsector were taken into account.

Land-Use Change & Forestry (5): Consideration was given to the burning of biomass that accompanies the conversion of forest land to other uses, and calculations were made on the basis of default methods indicated in the Revised 1996 IPCC Guidelines.

Waste (6): For the Waste Incineration (6C) subsector, the amounts of waste processed in Waste Incinerators designated by the Air Pollution Control Law were multiplied by the emission factors [12].

Other (7): Carbon monoxide emissions from tobacco smoke were calculated by multiplying the amount of carbon monoxide generated by each smoked item [25] by the total number of items smoked [26].

Table 2.14 Carbon Monoxide Emissions (Fiscal 1990 – 1999)

(Unit : Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	3,871.6	3,904.6	3,879.1	3,825.5	3,917.6	3,803.1	3,750.5	3,793.5	3,666.7	3,673.9
1 Energy	3,639.2	3,655.1	3,633.4	3,564.9	3,652.5	3,540.9	3,531.0	3,586.6	3,469.1	3,480.8
1A Fuel Combustion Activities	3,639.2	3,655.1	3,633.4	3,564.9	3,652.5	3,540.9	3,531.0	3,586.6	3,469.1	3,480.8
1A1. Energy Industries	57.7	58.1	57.1	56.4	56.5	58.8	54.6	54.8	53.3	56.3
1A2. Manufacturing Industries and Construction	1,509.7	1,468.6	1,461.9	1,454.5	1,602.8	1,437.2	1,451.1	1,487.9	1,396.5	1,387.9
1A3. Transport	2,043.8	2,099.8	2,084.5	2,022.2	1,963.0	2,010.5	1,990.6	2,009.4	1,985.8	2,002.3
1A4. Other Sectors	27.9	28.7	29.9	31.8	30.2	34.4	34.7	34.5	33.5	34.4
1A5. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1B Fugitive Emissions from Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2. Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 Industrial Processes	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
3 Solvent and Other Product Use										
4 Agriculture	162.1	165.2	160.9	174.5	172.2	174.0	163.1	150.2	139.4	135.1
4A Enteric Fermentation										
4B Manure Management										
4C Rice Cultivation										
4D Agricultural Soils										
4E Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4F Field Burning of Agricultural Residues	162.1	165.2	160.9	174.5	172.2	174.0	163.1	150.2	139.4	135.1
4G Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 Land-Use Change and Forestry	22.1	34.7	34.9	35.2	35.5	36.0	NE	NE	NE	NE
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion	22.1	34.7	34.9	35.2	35.5	36.0	NE	NE	NE	NE
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	30.5	31.6	31.7	32.7	39.1	33.8	37.2	38.6	39.7	39.7
6A Solid Waste Disposal on Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6B Wastewater Handling	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6C Waste Incineration	30.5	31.6	31.7	32.7	39.1	33.8	37.2	38.6	39.7	39.7
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	17.7	18.1	18.1	18.3	18.4	18.4	19.2	18.0	18.5	18.3
International Bunkers	64.5	69.4	71.7	77.8	79.3	77.5	64.9	74.3	75.7	73.5

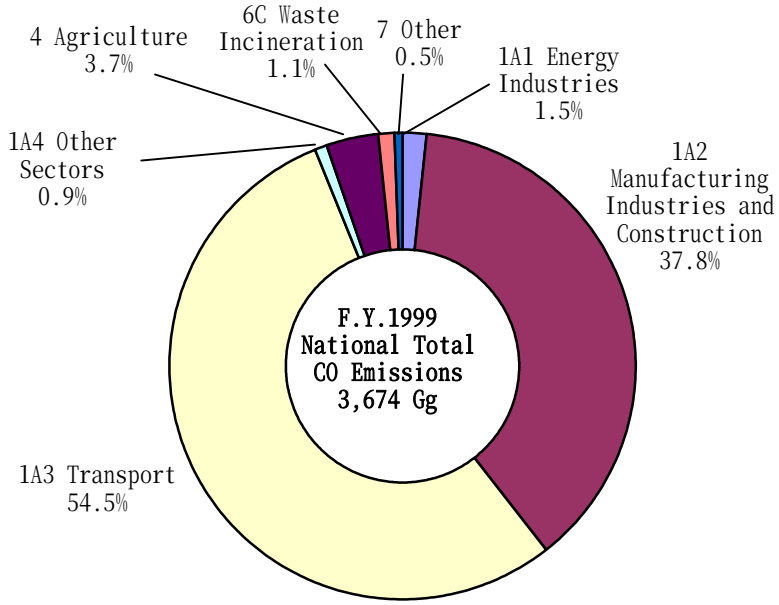

Figure 2.10 Breakdown of Carbon Monoxide Emissions (Fiscal 1999)

2.10 Non-Methane Volatile Organic Compounds (NMVOC)

2.10.1 Outline of Emissions

Japan generated approximately 1.85 million tons of non-methane volatile organic compounds (NMVOC) emissions in fiscal 1999, generated primarily in the Energy (1), Industrial Processes (2), and Solvent and Other Product Use (3) sectors.

Table 2.15 shows emissions from fiscal 1990, broken down by each sector. Overall emissions have declined slightly, reflecting a decline in the Solvent and Other Product Use (3) sector, which is the most main source of emissions. A slight decline also occurred in the Fuel Combustion Activities (1A) subsector, while an increase occurred in the Fugitive Emissions from Fuels (1B) subsector.

Figure 2.11 breaks down non-methane volatile organic compound emissions in fiscal 1999 according to sector. Emissions were the greatest in the Solvent and Other Product Use (3) sector, followed in descending order by the Energy (1) and Industrial Processes (2) sectors. The Solvent and Other Product Use (3) sector accounts for 70.2% of the total and includes emissions generated through the use of paints, oil removers and dry cleaning, as well as chemical products. The subsectors Fuel Combustion Activities (1A) and Fugitive Emissions from Fuels (1B) of the Energy (1) sector account for 12.4% and 12.8% of the total, respectively.

2.10.2 Methods of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing Industries and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion Activities (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission factors [12]. This is a "bottom-up" approach. The remainder of the Other Sectors (1A4) subsector involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars). Emissions for motor vehicles were calculated by determining the total distance traveled by each type of vehicle and multiplying by the emission factors [24]. In all others, the default emission factors of the revised 1996 IPCC Guidelines were used. Values shown in the Fugitive Emissions from Fuels (1B) subsector represent emissions from evaporation occurring during the handling of crude oil and petroleum products. The activity data for this subsector included the amounts handled or the amounts shipped [13], which were multiplied by the emission factors in accordance with how the materials were handled [27].

Industrial Processes (2): The amounts emitted through the manufacture of petroleum products (primarily in the petrochemical industry) were estimated. The amounts of such products produced [28] were multiplied by the emission factors [29].

Solvent and Other Product Use (3): The amounts of products produced or consumed in each application [28] were multiplied by the emission factors [27].

Waste (6): For the Waste Incineration (6C) subsector, the amounts of waste processed in the Waste Incinerator designated by the Air Pollution Control Law were multiplied by the emission factors [12].

Table 2.15 Non-Methane Volatile Organic Compounds Emissions (Fiscal 1990 – 1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	1,911.0	1,888.7	1,855.6	1,808.2	1,851.9	1,874.7	1,906.6	1,921.0	1,814.5	1,849.9
1 Energy	442.2	443.3	443.0	434.9	439.6	449.0	456.1	459.3	458.9	465.6
1A Fuel Combustion Activities	243.0	240.0	236.5	226.5	222.3	228.7	231.3	231.6	227.4	229.7
1A1. Energy Industries	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1A2. Manufacturing Industries and Construction	1.6	1.8	3.0	1.8	2.0	1.8	1.9	1.9	1.8	1.8
1A3. Transport	241.3	238.1	233.3	224.5	220.1	226.6	229.1	229.4	225.3	227.6
1A4. Other Sectors	0.0	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3
1A5. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1B Fugitive Emissions from Fuels	199.3	203.4	206.5	208.4	217.3	220.3	224.8	227.7	231.6	235.9
1B1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2. Oil and Natural Gas	199.3	203.4	206.5	208.4	217.3	220.3	224.8	227.7	231.6	235.9
2 Industrial Processes	80.9	81.1	79.8	76.3	79.4	83.3	85.3	86.9	82.7	86.0
3 Solvent and Other Product Use	1,387.8	1,364.3	1,332.8	1,297.0	1,332.9	1,342.3	1,365.1	1,374.8	1,272.8	1,298.2
4 Agriculture	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4A Enteric Fermentation										
4B Manure Management	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4C Rice Cultivation	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4D Agricultural Soils	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4E Prescribed Burning of Savannas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
4F Field Burning of Agricultural Residues	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
4G Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
5 Land-Use Change and Forestry										
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion										
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6A Solid Waste Disposal on Land	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6B Wastewater Handling	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
6C Waste Incineration	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International Bunkers	15.5	16.8	17.4	19.1	19.4	18.4	14.5	17.0	17.6	16.9

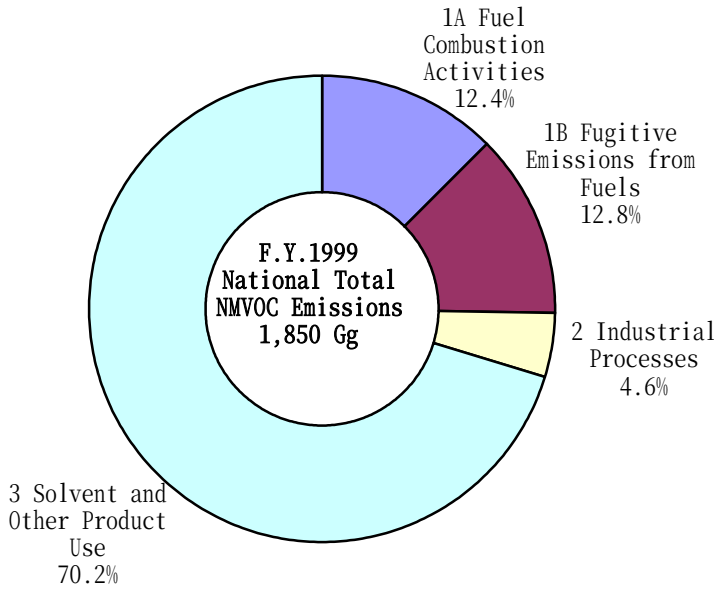

Figure 2.11 Breakdown of Non-Methane Volatile Organic Compounds Emissions (Fiscal 1999)

2.11 Sulfur Dioxide (SO_2)

2.11.1 Outline of Emissions

Japan emitted approximately 870,000 tons of sulfur dioxide in fiscal 1999.

Table 2.16 shows emissions from fiscal 1990 through 1999, broken down by sector. Overall emissions have declined. A significant decline was seen in the Transport (1A3) sector in fiscal 1993, reflecting declines in the sulfur amounts in fuel [30]. Emissions have also declined in Manufacturing Industries and Construction (1A2), and Industrial Processes (2). The Energy Industries (1A1) sector has fluctuated, while the Waste Incineration (6C) subsector has shown an increase even though the amount of emissions has fluctuated.

Figure 2.12 shows a breakdown of sulfur dioxide emissions in fiscal 1999 according to sector. Emissions were the greatest in the Manufacturing Industries and Construction (1A2) subsector, accounting for 41% of the total. The Energy Industries (1A1) subsector accounted for 26%. The Industrial Processes (2) sector includes emissions generated when sulfide minerals are smelted, accounting for 5% of the total.

2.11.2 Methods of Estimating Emissions

Energy (1): For the Energy Industries (1A1), Manufacturing Industries and Construction (1A2), and part of the Other Sectors (1A4) under the Fuel Combustion Activities (1A) sector, emissions were calculated for each soot and smoke-emitting facility designated by the Air Pollution Control Law

by multiplying the amounts of fuel consumed (broken down by type of furnace and type of fuel) by the emission factors [12]. This is a "bottom-up" approach. The remainder of the Other Sectors (1A4) subsector involves small boilers and fuel facilities, and emissions were calculated by multiplying the emission factors for different types of fuel and their applications by the amounts of fuel consumed. The figure shown in the Transport (1A3) subsector includes emissions from motor vehicles, ships, aircraft, and railways (diesel railcars).

Industrial Processes (2): Estimates were made for sulfur dioxide emissions from soot and smoke-emitting facilities designated by the Air Pollution Control Law [12].

Waste (6): For the Waste Incineration (6C) subsector, the amounts of waste processed in Waste Incinerators designated by the Air Pollution Control Law were multiplied by the emission factors [12].

Table 2.16 Sulfur Dioxide Emissions (Fiscal 1990-1999)

(Unit：Gg)

Fiscal Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	972.0	966.2	923.0	882.6	937.7	905.6	869.8	868.3	848.4	870.1
1 Energy	890.9	881.1	843.7	791.8	843.4	807.5	790.7	787.3	768.6	790.1
1A Fuel Combustion Activities	890.9	881.1	843.7	791.8	843.4	807.5	790.7	787.3	768.6	790.1
1A1. Energy Industries	238.6	236.0	248.7	230.0	250.9	225.9	217.5	214.9	209.1	221.6
1A2. Manufacturing Industries and Construction	379.7	359.1	356.8	367.8	382.3	362.3	357.2	357.5	344.7	353.7
1A3. Transport	185.8	202.0	149.6	88.4	91.0	95.4	99.0	98.8	96.7	97.0
1A4. Other Sectors	86.8	84.0	88.6	105.6	119.3	123.9	117.0	116.1	118.2	117.9
1A5. Other	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
1B Fugitive Emissions from Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B1. Solid Fuels	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1B2. Oil and Natural Gas	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
2 Industrial Processes	48.1	53.3	41.7	50.8	52.1	53.0	43.6	44.9	42.3	42.5
3 Solvent and Other Product Use										
4 Agriculture										
4A Enteric Fermentation										
4B Manure Management										
4C Rice Cultivation										
4D Agricultural Soils										
4E Prescribed Burning of Savannas										
4F Field Burning of Agricultural Residues										
4G Other										
5 Land-Use Change and Forestry										
5A Changes in Forest and Other Woody Biomass Stocks										
5B Forest and Grassland Conversion										
5C Abandonment of Managed Lands										
5D CO2 Emissions and Removals from Soil										
6 Waste	32.9	31.8	37.6	40.0	42.2	45.1	35.4	36.2	37.6	37.5
6A Solid Waste Disposal on Land										
6B Wastewater Handling										
6C Waste Incineration	32.9	31.8	37.6	40.0	42.2	45.1	35.4	36.2	37.6	37.5
6D Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
7 Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
International Bunkers	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO	NE、NO

Note: If there are two notation keys in subsectors, the both (i.e. NE and NO) are shown.

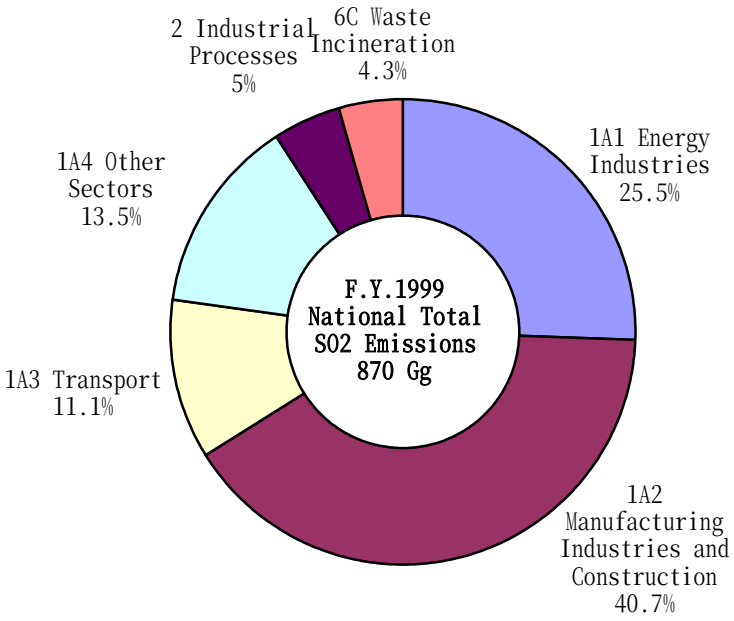

Figure 2.12 Breakdown of Sulfur Dioxide Emissions (Fiscal 1999)

References

(A publication data was omitted for the statistics that was referred for several years.)

1) IPCC (1997): Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories
2) IPCC (2000): Good Practice and Uncertainty Management in National Greenhouse Gas Inventories
3) Agency of Natural Resources and Energy: "General Energy Statistics"
4) Environment Agency: "The Estimation of CO_2 Emission in Japan (1992)"
5) Ministry of Economy, Trade and Industry (METI): "Yearbook of Minerals and Non-ferrous Metals Statistics"
6) METI: "Statistical Yearbook for the Ceramics and Building Materials Industries"
7) METI: "Current Survey of Energy Consumption in Commerce, Mining and Manufacturing"
8) Forestry Agency: "Statistical Handbook of Forestry"
9) Japan Environmental Sanitation Center (Incorporated Foundation): "Municipal Waste Composition Analysis"
10) Ministry of the Environment: "Industrial Waste Administration Research"
11) Environment Agency: "Research into Units and Total Vehicular Exhaust (1997)"
12) Ministry of the Environment: "Research of Air Pollutant Emissions from Stationary Sources"
13) METI: "Statistical Yearbook on Energy Supply and Demand"
14) Ministry of Agriculture, Forestry and Fisheries (MAFF): "Report of Livestock"
15) Japan Livestock Technology Association: "Control of Emissions of Greenhouse Gases from Livestock Farming (4^{th} Ed.) (1999)."
16) MAFF: "Crop Statistics"
17) Y. Matsuzawa et al (1993): "Estimate of the Methane Emissions from Final Disposal Landfill Site," from the proceedings of the 4^{th} Annual Conference of the Japan Society of Waste Management Experts.
18) Production amounts and fiscal 1999 emission factors were determined through manufacturer hearings; emission factors from fiscal 1990-98 were derived from a study conducted by Miyazaki Prefecture and the Environment Agency (1995) entitled: "Study of Greenhouse Gas Emission Factors from Stationary Sources."
19) Production amounts from METI: "Statistical Yearbook on the Chemical Industry". Emission factors were determined through manufacturer hearings.
20) Ministry of Health, Labour and Welfare (MHLW): "Statistics of Production by Pharmaceutical Industry."
21) Amounts of fertilizer used determined through the MAFF: "Pocket Handbook of Fertilizers".
22) Average value of NO_x discharge ratio out of the nitrogen amounts in fertilizer used, acquired through research carried out by 45 prefectural agricultural test centers nationwide.
23) The amount of incinerated sewage sludge was determined through studies by the Japan Sewage Works Association. Emissions factors were determined by the Public Works Research Institute of the

Ministry of Construction (1994): “Technical Memorandum of PWRI.”

24) Distances traveled were based on data from the Ministry of Transport: “Statistical Yearbook of Motor Vehicle Transport.” Emissions factors were based on Environment Agency materials.
25) Data from manufacturer hearings.
26) Tobacco Institute of Japan: “Total Domestic Cigarette Consumption.”
27) Environment Agency materials.
28) METI: mostly from the “Statistical Yearbook on the Chemical Industry”
29) Researched by the Petroleum Association of Japan