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**National Greenhouse Gas Inventory Report of JAPAN (2009)**

**Edited by**

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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).

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 ($SO_2$)).

The structure of this report is fully in line with the recommended structure indicated in the Annex I of UNFCCC Inventory Reporting Guidelines (FCCC/SBSTA/2006/9).

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 source, etc.) from since the previous submission.

Annex offers additional information to assist further understanding of Japan's inventory. The background data submitted to the secretariat provides the complete process of estimating 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, 2009
Climate Change Policy Division
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. 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 before the beginning of the commitment period (2007). The GHGs inventories have been therefore important data for Japan in reporting its achievement of the Kyoto Protocol's commitment. In 2006, Japan submitted the Report on Japan's Assigned Amount pursuant to Article 3, Paragraphs 7 and 8 of the Kyoto Protocol to the Secretariat of the United Nations Framework Convention on Climate Change, and in 2007, the Report was approved by the Compliance Committee under the Conference of the Parties serving as the meeting of the Parties (COP/MOP).

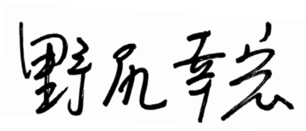
Estimation of GHGs emissions has started in Japan since the latter half of the 1980s. Since 1992, with the cooperation of ministries, the Ministry of the Environment (previously named as the Environment Agency) has estimated carbon dioxide emissions and has submitted annual reports to the Council of Ministers for Global Environmental Conservation every year. The Government also publicizes total emissions of greenhouse gases in Japan.

The GHGs inventory 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 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 those 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 Climate Change Policy Division of the Global Environment Bureau of the Ministry of the Environment for their efforts and support to the establishment of GIO in July 2002.

My appreciation also extends to Mr. Kiyoto TANABE, a GIO researcher who polished contents of this report; Ms. Masako WHITE, our secretary who conducted relevant administrative duties including the liaison with the Convention Secretariat; and Ms. Tamaki SAKANO who proofread this report.

April, 2009



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Center for Global Environmental Research

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# Executive Summary of National GHGs Inventory Report of Japan 2009

## E.S.1. Background Information on Greenhouse Gas Inventories and Climate Change

This National Inventory Report comprises the inventory of the emissions and removals of greenhouse gases, indirect greenhouse gases and $SO_2$ in Japan for FY 1990 through to 2007[1], on the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC).

Estimation methodologies of greenhouse gas inventories should be 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 2000, the *Good Practice and Uncertainty Management in National Greenhouse Gas Inventories (2000)* (hereafter, *the Good Practice Guidance (2000)*) was published. The Guidance presents the methods for choosing methodologies appropriate to the circumstances of each country and quantitative methods for evaluating uncertainty. Parties are required to seek to apply the *Good Practice Guidance (2000)* to their inventory reporting from 2001 and afterward.

For the submission of Japan's inventories, the trial use of the *UNFCCC Reporting Guidelines on Annual Inventories* (FCCC/SBSTA/2006/9) has been determined by the Conference of the Parties, and the inventory will be reported in accordance with this guideline. For the preparation of the LULUCF inventory, the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereafter, *LULUCF-GPG*) was published in 2003, and parties are required to seek to apply the *LULUCF-GPG* to their inventory reporting from 2005 and afterward.

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

Total greenhouse gas emission in FY 2007 (the sum of emissions of each type of greenhouse gas multiplied by its global warming potential [GWP][2]; except for carbon dioxide removals) was 1,374 million tons (in $CO_2$ equivalents), an increase by 13.8% from FY 1990. Compared to emissions in the base year under the Kyoto Protocol (FY 1990 for emissions of $CO_2$, $CH_4$, $N_2O$; FY 1995 for emissions of HFCs, PFCs, and $SF_6$), it increased by 9.0%. Removals of carbon dioxide in FY 2007 were 81.4 million tons[3], an increase by 9.4% from FY 1990.

It should be noted that actual emissions of HFCs, PFCs and $SF_6$ in the period from 1990 to 1994 have not been estimated (NE)[4].

[1] "FY (Fiscal Year)" is used because $CO_2$ is the primary GHGs emissions and estimated on the fiscal year basis; from April of the year to March of the next year.

[2] Global Warming Potential (GWP): It is the coefficients that indicate degrees of greenhouse gas effects caused by greenhouse gases converted into the proportion of equivalent degrees of $CO_2$. The coefficients are subjected to the *Second National Assessment Report* (1995) issued by the Intergovernmental Panel on Climate Change (IPCC).

[3] In the inventory submitted under the FCCC, removals by forest planted before 1990 are contained. Therefore, this value do not correspond to 13 Mt indicated in the annex of Decision 16/CMP.1 (Land use, land-use change and forestry) adopted in COP/MOP1.

[4] Potential emissions are reported in CRF for 1990-1994.

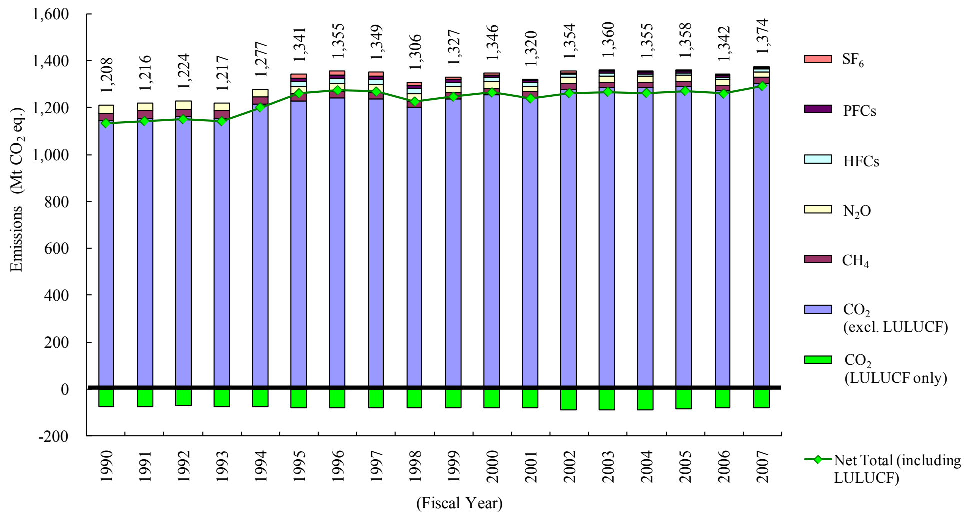


Figure 1　Trends in emission and removals of greenhouse gases in Japan

Table 1　Trends in emission and removals of greenhouse gases in Japan

| [Mt $CO_2$ eq.] | GWP | Base year of KP | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (excl. LULUCF) | 1 | 1,144.1 | 1,143.2 | 1,152.6 | 1,160.8 | 1,153.6 | 1,213.5 | 1,226.6 | 1,238.9 | 1,234.9 | 1,198.9 | 1,233.9 | 1,254.6 |
| $CO_2$ (incl. LULUCF) | 1 | NA | 1,068.8 | 1,078.4 | 1,087.0 | 1,078.6 | 1,137.8 | 1,147.0 | 1,159.0 | 1,154.7 | 1,118.8 | 1,153.6 | 1,174.0 |
| $CO_2$ (LULUCF only) | 1 | NA | -74.4 | -74.3 | -73.9 | -74.9 | -75.7 | -79.5 | -79.9 | -80.1 | -80.0 | -80.3 | -80.7 |
| $CH_4$ (excl. LULUCF) | 21 | 33.4 | 32.6 | 32.4 | 32.1 | 31.8 | 31.1 | 30.2 | 29.5 | 28.5 | 27.6 | 27.0 | 26.4 |
| $CH_4$ (incl. LULUCF) | 21 | NA | 32.6 | 32.4 | 32.1 | 31.9 | 31.2 | 30.2 | 29.6 | 28.5 | 27.7 | 27.0 | 26.4 |
| $N_2O$ (excl. LULUCF) | 310 | 32.6 | 32.0 | 31.5 | 31.5 | 31.3 | 32.5 | 32.8 | 33.9 | 34.6 | 33.1 | 26.7 | 29.3 |
| $N_2O$ (incl. LULUCF) | 310 | NA | 32.1 | 31.5 | 31.6 | 31.3 | 32.5 | 32.9 | 33.9 | 34.6 | 33.1 | 26.8 | 29.3 |
| HFCs | HFC-134a : 1,300 etc. | 20.2 | NE | NE | NE | NE | NE | 20.3 | 19.9 | 19.9 | 19.4 | 19.9 | 18.8 |
| PFCs | PFC-14 : 6,500 etc. | 14.0 | NE | NE | NE | NE | NE | 14.4 | 14.9 | 16.3 | 13.5 | 10.6 | 9.7 |
| $SF_6$ | 23,900 | 16.9 | NE | NE | NE | NE | NE | 17.0 | 17.5 | 15.0 | 13.6 | 9.3 | 7.3 |
| Gross Total (excluding LULUCF) | | 1,261.3 | 1,207.8 | 1,216.5 | 1,224.5 | 1,216.7 | 1,277.1 | 1,341.2 | 1,354.7 | 1,349.1 | 1,306.2 | 1,327.5 | 1,346.0 |
| Net Total (including LULUCF) | | NA | 1,133.5 | 1,142.3 | 1,150.7 | 1,141.8 | 1,201.4 | 1,261.7 | 1,274.9 | 1,269.0 | 1,226.2 | 1,247.2 | 1,265.4 |

| [Mt $CO_2$ eq.] | GWP | Base year of KP | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Emission increase from the base year of KP | Emission increase from 1990 (2007) | Emission increase from 1995 (2007) | Emission increase from previous year (2007) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (excl. LULUCF) | 1 | 1,144.1 | 1,238.8 | 1,276.7 | 1,283.9 | 1,282.5 | 1,287.3 | 1,270.2 | 1,303.8 | 14.0% | 14.0% | - | 2.6% |
| $CO_2$ (incl. LULUCF) | 1 | NA | 1,158.0 | 1,185.6 | 1,192.5 | 1,190.9 | 1,201.7 | 1,188.4 | 1,222.4 | - | 14.4% | - | 2.9% |
| $CO_2$ (LULUCF only) | 1 | NA | -80.8 | -91.1 | -91.4 | -91.6 | -85.6 | -81.7 | -81.4 | - | 9.4% | - | -0.5% |
| $CH_4$ (excl. LULUCF) | 21 | 33.4 | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 | 22.6 | -32.3% | -30.7% | - | -1.9% |
| $CH_4$ (incl. LULUCF) | 21 | NA | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 | 22.6 | - | -30.7% | - | -1.9% |
| $N_2O$ (excl. LULUCF) | 310 | 32.6 | 25.8 | 25.5 | 25.2 | 25.3 | 24.8 | 24.7 | 23.8 | -27.1% | -25.6% | - | -3.8% |
| $N_2O$ (incl. LULUCF) | 310 | NA | 25.8 | 25.5 | 25.2 | 25.3 | 24.9 | 24.7 | 23.8 | - | -25.8% | - | -3.8% |
| HFCs | HFC-134a : 1,300 etc. | 20.2 | 16.2 | 13.7 | 13.8 | 10.6 | 10.6 | 11.6 | 13.2 | -34.6% | - | -34.8% | 13.7% |
| PFCs | PFC-14 : 6,500 etc. | 14.0 | 8.1 | 7.5 | 7.3 | 7.5 | 7.1 | 7.4 | 6.5 | -53.8% | - | -54.9% | -12.2% |
| $SF_6$ | 23,900 | 16.9 | 6.0 | 5.7 | 5.4 | 5.3 | 4.6 | 5.1 | 4.4 | -74.1% | - | -74.1% | -14.8% |
| Gross Total (excluding LULUCF) | | 1,261.3 | 1,320.5 | 1,353.7 | 1,359.7 | 1,355.0 | 1,357.8 | 1,342.1 | 1,374.3 | 9.0% | 13.8% | 2.5% | 2.4% |
| Net Total (including LULUCF) | | - | 1,239.7 | 1,262.7 | 1,268.4 | 1,263.4 | 1,272.3 | 1,260.4 | 1,292.9 | - | 14.1% | | 2.6% |

*NA: Not Applicable, NE: Not Estimated

* $CH_4$ and $N_2O$ emissions in Table 1 include emissions from Land-Use Change and Forestry based on the estimation method decided by the UNFCCC. On the contrary, since emissions from Land-Use Change and Forestry are regarded as RMU (removal unit) according to Article 3.3 of the Kyoto Protocol, they are not included in GHG emissions based on Kyoto Protocol (refer annex 8 table 1).

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

The breakdown of emissions and removals of greenhouse gases in FY 2007 by sector[5] shows that the Energy sector accounted for 90.6%, followed by Industrial processes at 5.7%, Solvents and other product use at 0.02%, Agriculture at 1.9% and Waste at 1.8% of total annual greenhouse gas emissions.

Removals by Land-use land use change and forestry in FY2007 were equivalent to 5.9% of total annual greenhouse gas emissions.

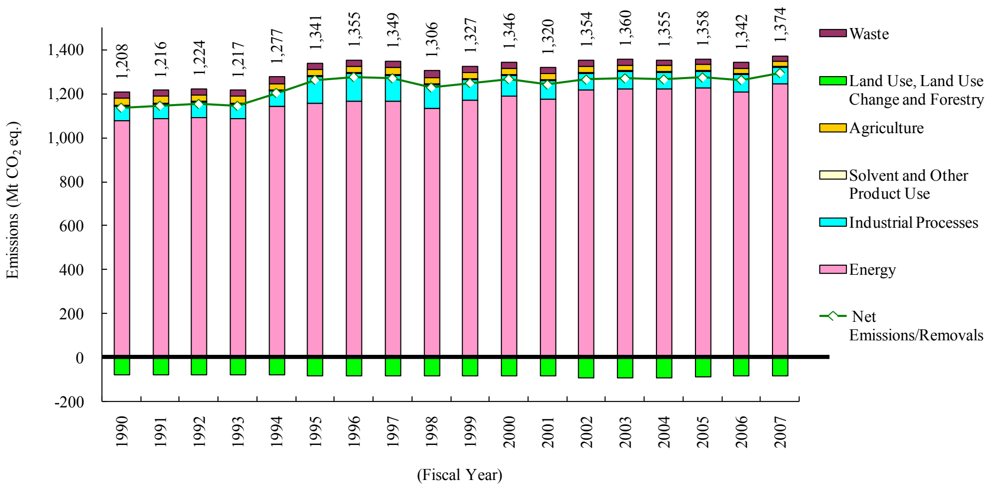


Figure 2 Trends in emissions and removals of greenhouse gases in each category

Table2 Trends in emissions and removals of greenhouse gases in each category

| [Mt $CO_2$ eq.] | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy | 1,078.9 | 1,086.8 | 1,094.2 | 1,087.7 | 1,143.8 | 1,156.7 | 1,169.0 | 1,166.0 | 1,135.8 | 1,171.2 |
| Industrial Processes | 70.9 | 71.7 | 71.3 | 70.3 | 72.6 | 124.3 | 125.9 | 123.5 | 111.6 | 98.3 |
| 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 |
| Agriculture | 31.6 | 31.5 | 31.4 | 31.3 | 30.9 | 30.3 | 29.6 | 29.0 | 28.6 | 28.1 |
| Land Use, Land Use Change and Forestry | -74.3 | -74.2 | -73.8 | -74.9 | -75.6 | -79.5 | -79.8 | -80.1 | -80.0 | -80.3 |
| Waste | 26.1 | 26.1 | 27.2 | 26.9 | 29.3 | 29.5 | 29.8 | 30.2 | 29.9 | 29.5 |
| Net Emissions/Removals | 1,133.5 | 1,142.3 | 1,150.7 | 1,141.8 | 1,201.4 | 1,261.7 | 1,274.9 | 1,269.0 | 1,226.2 | 1,247.2 |
| Emissions | 1,207.8 | 1,216.5 | 1,224.5 | 1,216.7 | 1,277.1 | 1,341.2 | 1,354.7 | 1,349.1 | 1,306.2 | 1,327.5 |

| [Mt $CO_2$ eq.] | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Energy | 1,191.1 | 1,178.4 | 1,218.4 | 1,224.2 | 1,224.2 | 1,228.4 | 1,211.0 | 1,244.5 |
| Industrial Processes | 97.4 | 86.6 | 80.9 | 80.0 | 77.8 | 77.5 | 79.8 | 78.8 |
| Solvent and Other Product Use | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 |
| Agriculture | 27.9 | 27.6 | 27.4 | 27.2 | 27.0 | 26.8 | 26.7 | 26.5 |
| Land Use, Land Use Change and Forestry | -80.6 | -80.8 | -91.0 | -91.3 | -91.6 | -85.6 | -81.7 | -81.4 |
| Waste | 29.3 | 27.6 | 26.8 | 28.0 | 25.8 | 24.8 | 24.4 | 24.2 |
| Net Emissions/Removals | 1,265.4 | 1,239.7 | 1,262.7 | 1,268.4 | 1,263.4 | 1,272.3 | 1,260.4 | 1,292.9 |
| Emissions | 1,346.0 | 1,320.5 | 1,353.7 | 1,359.7 | 1,355.0 | 1,357.8 | 1,342.1 | 1,374.3 |

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

## E.S.4. Other Information (Indirect Greenhouse Gases and $SO_2$)

Under UNFCCC, it is required to report emissions of indirect greenhouse gases ($NO_X$, CO and NMVOC) and $SO_2$, other than 6 types of greenhouse gases ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs and $SF_6$) which are not controlled by the Kyoto Protocol. Emission trends of these gases are indicated below.

Nitrogen oxide ($NO_X$) emissions in FY2007 were 1,943 Gg, a decrease by 4.7% compared to FY1990, and by 2.6% compared to the previous year.

Carbon monoxide (CO) emissions in FY2007 were 2,761 Gg, a decrease by 38.1% compared to FY1990, and by 3.4% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY2007 were 1,638 Gg, a decrease by 15.4% compared to FY1990, and a decrease by 1.1% compared to the previous year.

Sulfur dioxide ($SO_2$) emissions in FY2007 were 780 Gg, a decrease by 22.9% compared to FY1990, and by 3.0% compared to the previous year.

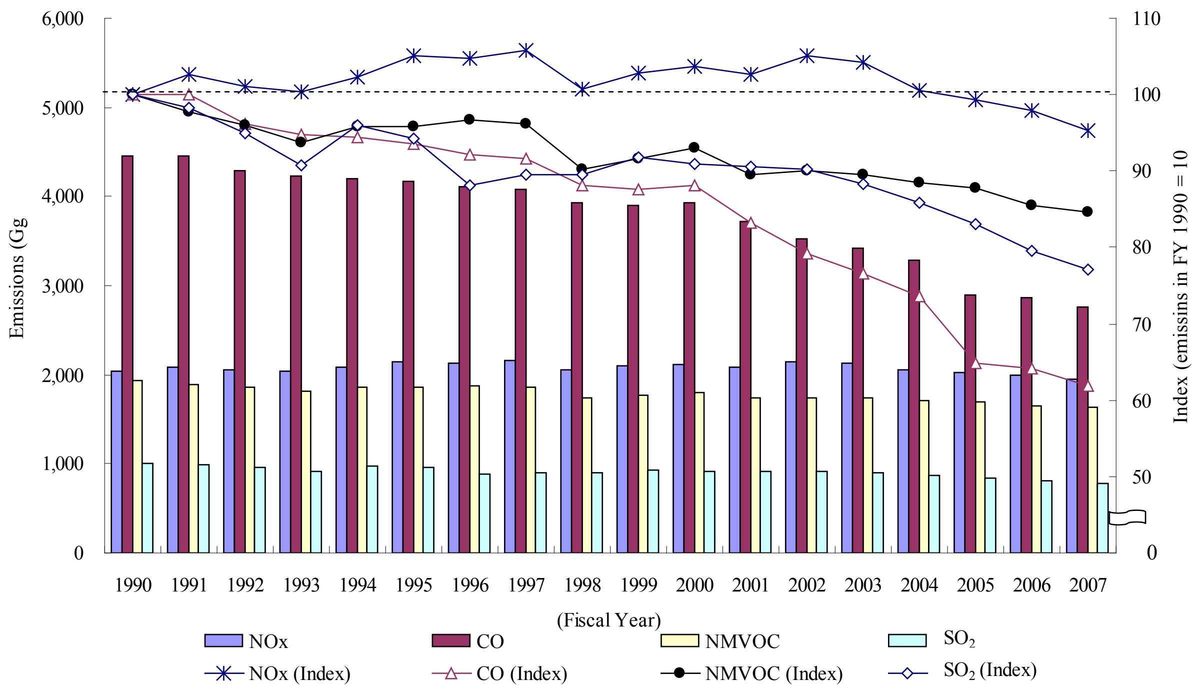


Figure 3 Trends in Emissions of Indirect Greenhouse Gases and $SO_2$

# Chapter 1 Introduction

## 1.1. Background Information on Japan's Greenhouse Gas Inventory

The National Inventory Report (NIR) is comprised of the inventories of the emissions and removals of greenhouse gases (GHGs), including indirect GHGs and $SO_2$ in Japan from FY 1990 to FY 2007[1], on the basis of Article 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC).

Estimation methodologies for the GHG inventories should be in line with the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*Revised 1996 IPCC Guidelines*), which was developed by the Intergovernmental Panel on Climate Change (IPCC). In 2000, the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)* (*GPG (2000)*) was published. This Guidance presents the methods for choosing methodologies appropriate to the circumstances of each country and quantitative methods for evaluating uncertainty. Parties are required to attempt to apply the *GPG (2000)* to their inventory reporting from 2001 and afterwards.

Japan's national inventory is reported in accordance with the *UNFCCC Reporting Guidelines on Annual Inventories* (FCCC/SBSTA/2006/9). With regard to the preparation of the LULUCF inventory, parties are required to attempt the application of the *IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*LULUCF-GPG*), published in 2003, to their inventory reporting from 2005 and afterwards.

## 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, which is annually submitted to the UNFCCC Secretariat in accordance with the UNFCCC and the Kyoto Protocol. The MOE takes overall responsibilities for the national inventory and therefore also makes an effort on improving its quality. For instance, the MOE organizes "the Committee for the Greenhouse Gas Emission Estimation Methods (the 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 Format (CRF) and 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. The relevant ministries check and verify these inventories (i.e., CRF, NIR, KP-CRF and KP-NIR) including the spreadsheets that are actually utilized for the estimation, as a part of the Quality Control (QC) activities. The checked and verified inventory data are Japan's official values. They are then made public by the MOE and the national inventory is submitted to the UNFCCC Secretariat by the Ministry of Foreign Affairs.

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

Figure 1-1 shows the overall institutional arrangement for the inventory preparation within Japan. 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.

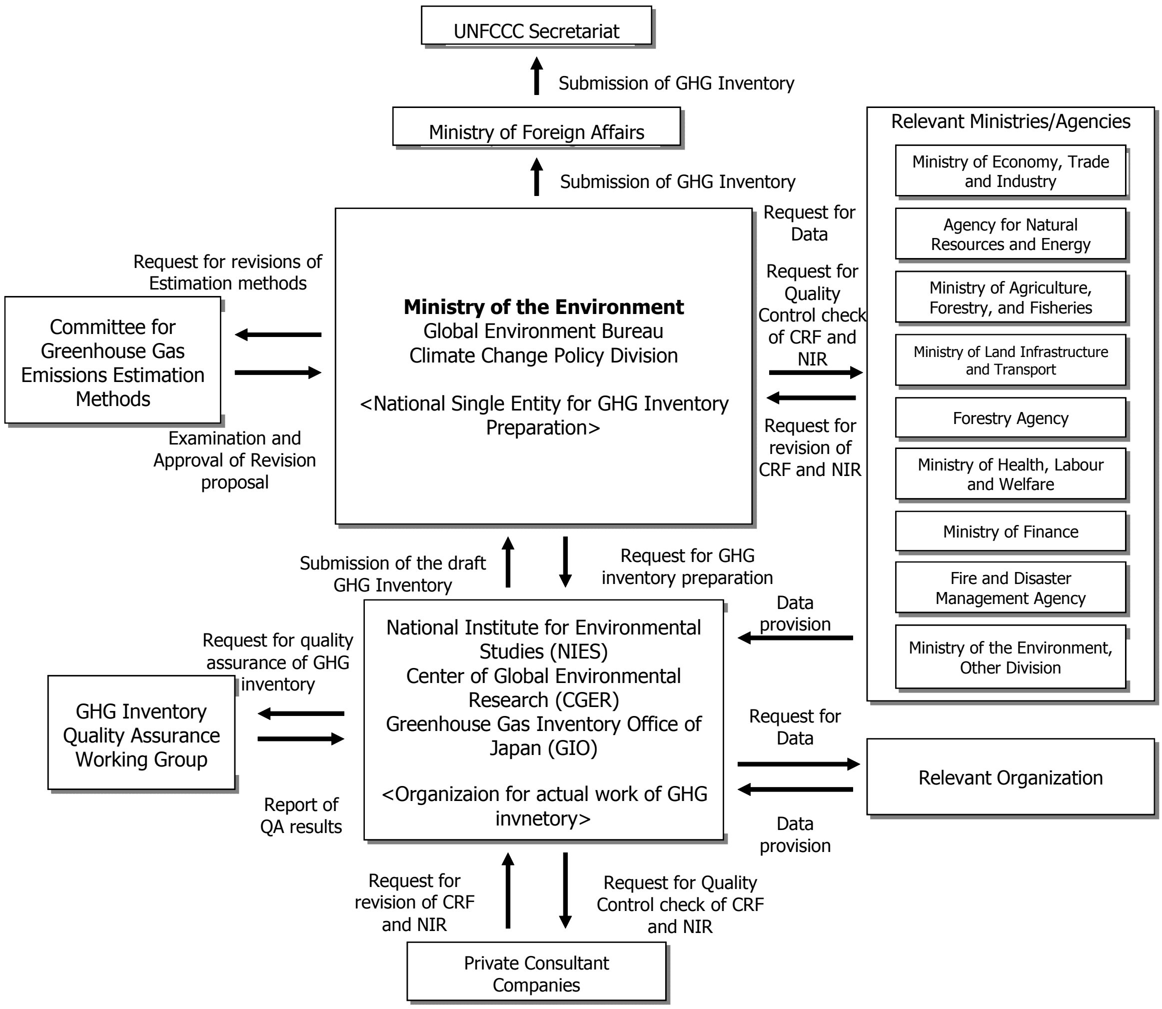


Figure 1-1 Japan's institutional arrangement for the national inventory preparation

## 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 | |
| | | | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May |
| 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 | | | | | | | | | | | Note ★ | |
| 9 | Holding the meeting of the QA-WG | MOE, GIO | → | → | → | → | | | | | | | | → |

Note: 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
The Committee: The Committee for the Greenhouse Gas Emission Estimation Methods
The QA-WG: The 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 (the QA-WG)”, 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 (the final figures) (Step 3)*

The data required for preparing the national inventory 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 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 drafts of NIR and KP-NIR are prepared by following the general guidelines made by the MOE and the GIO. These entities identify the points, which need to be revised or which require an additional description by taking the discussion at step 1 into account. The GIO and the selected private consulting companies prepare new NIR and KP-NIR by updating data, and by adding and revising descriptions in the previous NIR and KP-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 $0^{th}$ draft) prepared by the GIO (exterior QC). These 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 $0^{th}$ draft) prepared by the GIO.

Subsequently, the GIO sends out the primary drafts of the inventories as well as of official announcements as electronic computer files to the MOE and the relevant ministries and agencies, and possible revisions are carried out by them. These primary drafts include not only the drafts, to which the exterior QC was applied, but also the drafts of KP-CRF and KP-NIR that are prepared by the selected private consulting companies. The data, which are estimated based on confidential data, are only sent out for confirmation to the ministry and/or the agency which provided them.

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

When revisions are requested at step 6, the possible corrections are discussed among the MOE, the GIO and the relevant ministries and/or agencies. The corrected drafts are then the secondary drafts. These secondary drafts are sent out again to the relevant ministries and/or the agencies for conclusive confirmation. If there is no additional request for revision, they are considered to be the final versions.

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

The completed inventory is submitted by the MOE via the Ministry of Foreign Affairs to the UNFCCC Secretariat. Information on the estimated GHG emissions and removals is officially made public and is published on the MOE's homepage (http://www.env.go.jp/) complete with any 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 QA-WG, 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 QA-WG verifies the validation of the following information: estimation methodologies, activity data, emission factors, and the contents of CRF and NIR.
GIO integrates the items, which were suggested for improvement by the QA-WG, into the inventory improvement program, 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 *LULUCF-GPG*. 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 situation of emissions 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 *LULUCF-GPG* are used for: 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 *LULUCF-GPG* (Tier 1, Tier 2 level assessment and trend assessment, and qualitative analysis).

This analysis identified 37 sources and sinks as Japan's key categories in FY 2007 (Table 1-2). The same analysis was also conducted for the base year of the UNFCCC (FY 1990) in response to the reviewers' recommendation. A total of 33 sources and sinks were identified as key categories in the base year (Table 1-3). More detailed information is described in Annex 1.

Table 1-2 Japan's key source categories in FY 2007

| | A IPCC Category | | B Direct GHGs | L1 | T1 | L2 | T2 |
|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Solid Fuels | $CO_2$ | #1 | #2 | #3 | #7 |
| #2 | 1A Stationary Combustion | Liquid Fuels | $CO_2$ | #2 | #1 | #8 | #8 |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | $CO_2$ | #3 | #5 | #4 | |
| #4 | 1A Stationary Combustion | Gaseous Fuels | $CO_2$ | #4 | #3 | | |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | $CO_2$ | #5 | | #6 | |
| #6 | 2A Mineral Product | 1. Cement Production | $CO_2$ | #6 | #6 | #7 | #11 |
| #7 | 1A Stationary Combustion | Other Fuels | $CO_2$ | #7 | #11 | #14 | #14 |
| #8 | 6C Waste Incineration | | $CO_2$ | #8 | | #2 | #21 |
| #9 | 1A3 Mobile Combustion | d. Navigation | $CO_2$ | #9 | | | |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | $CO_2$ | #10 | | #13 | |
| #11 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 1. Refrigeration and Air Conditioning | HFCs | #11 | #8 | #5 | #2 |
| #12 | 1A3 Mobile Combustion | a. Civil Aviation | $CO_2$ | #12 | #15 | | |
| #13 | 2A Mineral Product | 2. Lime Production | $CO_2$ | #13 | | #22 | |
| #14 | 4A Enteric Fermentation | | $CH_4$ | | | #25 | |
| #15 | 4C Rice Cultivation | | $CH_4$ | | | #19 | #22 |
| #16 | 4B Manure Management | | $N_2O$ | | | #12 | #20 |
| #17 | 1A Stationary Combustion | | $N_2O$ | | | #18 | #17 |
| #18 | 6A Solid Waste Disposal on Land | | $CH_4$ | | #13 | #20 | #9 |
| #19 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | | | #10 | |
| #20 | 4D Agricultural Soils | 1. Direct Soil Emissions | $N_2O$ | | | #9 | #12 |
| #21 | 4D Agricultural Soils | 3. Indirect Emissions | $N_2O$ | | | #15 | #18 |
| #22 | 1A3 Mobile Combustion | b. Road Transportation | $N_2O$ | | | #16 | #10 |
| #23 | 4B Manure Management | | $CH_4$ | | | #17 | #19 |
| #24 | 6C Waste Incineration | | $N_2O$ | | | #11 | #16 |
| #25 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 5. Solvents | PFCs | | #9 | | #4 |
| #26 | 5E Settlements | 2. Land converted to Settlements | $CO_2$ | | #18 | | #25 |
| #27 | 5A Forest Land | 2. Land converted to Forest Land | $CO_2$ | | #12 | | |
| #28 | 2E Production of Halocarbons and | 2. Fugitive Emissions | $SF_6$ | | #14 | #21 | #3 |
| #29 | 6B Wastewater Handling | | $N_2O$ | | | #23 | |
| #30 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | $SF_6$ | | #7 | | #1 |
| #31 | 2E Production of Halocarbons and | 2. Fugitive Emissions | PFCs | | | #26 | |
| #32 | 2B Chemical Industry | 3. Adipic Acid | $N_2O$ | | #10 | | #15 |
| #33 | 5B Cropland | 2. Land converted to Cropland | $CO_2$ | | | | #24 |
| #34 | 2E Production of Halocarbons and $SF_6$ | 1. By-product Emissions (Production of HCFC-22) | HFCs | | #4 | | #13 |
| #35 | 1A3 Mobile Combustion | a. Civil Aviation | $N_2O$ | | | #1 | #5 |
| #36 | 1A3 Mobile Combustion | d. Navigation | $N_2O$ | | | #24 | |
| #37 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under gr.) | $CH_4$ | | #16 | | #6 |

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 source categories in FY 1990

| | A IPCC Category | | B Direct GHGs | L1 | L2 |
|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Liquid Fuels | $CO_2$ | #1 | #8 |
| #2 | 1A Stationary Combustion | Solid Fuels | $CO_2$ | #2 | #4 |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | $CO_2$ | #3 | #6 |
| #4 | 1A Stationary Combustion | Gaseous Fuels | $CO_2$ | #4 | |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | $CO_2$ | #5 | #7 |
| #6 | 2A Mineral Product | 1. Cement Production | $CO_2$ | #6 | #10 |
| #7 | 2E Production of Halocarbons and $SF_6$ | 1. By-product Emissions (Production of HCFC-22) | HFCs | #7 | #26 |
| #8 | 1A3 Mobile Combustion | d. Navigation | $CO_2$ | #8 | |
| #9 | 6C Waste Incineration | | $CO_2$ | #9 | #2 |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | $CO_2$ | #10 | #19 |
| #11 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 8. Electrical Equipment | $SF_6$ | #11 | #5 |
| #12 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 5. Solvents | PFCs | #12 | #9 |
| #13 | 1A Stationary Combustion | Other Fuels | $CO_2$ | #13 | #25 |
| #14 | 6A Solid Waste Disposal on Land | | $CH_4$ | #14 | #15 |
| #15 | 4A Enteric Fermentation | | $CH_4$ | #15 | #28 |
| #16 | 2B Chemical Industry | 3. Adipic Acid | $N_2O$ | #16 | |
| #17 | 2A Mineral Product | 2. Lime Production | $CO_2$ | #17 | #23 |
| #18 | 1A3 Mobile Combustion | a. Civil Aviation | $CO_2$ | #18 | |
| #19 | 4C Rice Cultivation | | $CH_4$ | | #20 |
| #20 | 4B Manure Management | | $N_2O$ | | #14 |
| #21 | 2E Production of Halocarbons and $SF_6$ | 2. Fugitive Emissions | $SF_6$ | | #3 |
| #22 | 4D Agricultural Soils | 1. Direct Soil Emissions | $N_2O$ | | #11 |
| #23 | 1A3 Mobile Combustion | b. Road Transportation | $N_2O$ | | #13 |
| #24 | 4D Agricultural Soils | 3. Indirect Emissions | $N_2O$ | | #16 |
| #25 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | | #17 |
| #26 | 4B Manure Management | | $CH_4$ | | #18 |
| #27 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under gr.) | $CH_4$ | | #12 |
| #28 | 6B Wastewater Handling | | $CH_4$ | | #27 |
| #29 | 6C Waste Incineration | | $N_2O$ | | #21 |
| #30 | 6B Wastewater Handling | | $N_2O$ | | #22 |
| #31 | 2B Chemical Industry | Other products except Anmonia | $CO_2$ | | #29 |
| #32 | 1A3 Mobile Combustion | d. Navigation | $N_2O$ | | #24 |
| #33 | 1A3 Mobile Combustion | a. Civil Aviation | $N_2O$ | | #1 |

N.B. Figures recorded in the column L (Level) indicate the ranking of level assessments.
The data of HFCs, PFCs and $SF_6$ utilized for this analysis are the 1995 values.

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

The QC activities (e.g., checking estimation accuracy, archiving documents) were carried out in each step of the inventory preparation process in accordance with the *GPG (2000)* in order to control the inventory's quality.

The evaluation and verification processes on estimation methods, which are done by experts within the Committee, were considered to be a QA activity. The experts who are not involved in any inventory preparation processes evaluated and verified the data quality from the view points of scientific knowledge and data availability.

In FY 2008, the QA/QC plan was revised by taking the Expert Review Team's recommendations into consideration. Under the revised QA/QC plan, Japan reviewed the national system and process for inventory preparation including QA/QC activities, and enhanced and systematized its national system and QC activities. As a QA activity, the QA-WG is newly established in order to implement the detailed review of sources and sinks. The QA-WG is composed of experts who are not directly involved in or related to the inventory preparation process. The process includes providing and preparation of activity data, developing emission factors, estimating GHG emissions and removals, and revising the estimation methodologies.

The new aspects of the QA/QC plan are:

1. <u>Clear descriptions of the national system for the inventory preparation and the role of each relevant entity</u>

   The role and the responsibility for each entity in the inventory preparation process are clarified (Figure 1-1). The relevant entities are: MOE, GIO, relevant ministries, relevant agencies, relevant organizations, the Committee, the QA-WG and selected private consulting companies.

2. <u>New Establishment of the Inventory Quality Assurance Working Group (the QA-WG)</u>

   As a QA activity, the QA-WG is newly established in order to implement a detailed review for each source or sink. The QA-WG is composed of experts who are not directly involved in or related to the inventory preparation process.

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

Total net GHG emissions in Japan for FY 2007 were approximately 1,293 million tons (carbon dioxide equivalents). The total emissions uncertainty was 1% and the uncertainty introduced into the trend in the total emissions was 2%. More detailed information on the uncertainty assessment is described in Annex 7.

Table 1-4 Uncertainty of Japan's Total Emissions

| IPCC Category | GHGs | Emissions / Removals [Gg $CO_2$ eq.] A | [%] | Combined Uncertainty [%] 1) B | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|
| 1A. Fuel Combustion ($CO_2$) | $CO_2$ | 1,235,227.4 | 95.5% | 1% | 10 | 0.69% | 2 |
| 1A. Fuel Combustion (Stationary:$CH_4$,$N_2O$) | $CH_4$、$N_2O$ | 5,819.2 | 0.5% | 27% | 3 | 0.12% | 7 |
| 1A. Fuel Combustion (Transport:$CH_4$,$N_2O$) | $CH_4$、$N_2O$ | 2,992.5 | 0.2% | 371% | 1 | 0.86% | 1 |
| 1B. Fugitive Emissions from Fuels | $CO_2$、$CH_4$、$N_2O$ | 454.1 | 0.0% | 19% | 5 | 0.01% | 8 |
| 2. Industrial Processes ($CO_2$,$CH_4$,$N_2O$) | $CO_2$、$CH_4$、$N_2O$ | 54,723.8 | 4.2% | 7% | 7 | 0.31% | 6 |
| 2. Industrial Processes (HFCs,PFCs,$SF_6$) | HFCs、PFCs、$SF_6$ | 24,078.6 | 1.9% | 24% | 4 | 0.44% | 4 |
| 3. Solvent & other Product Use | $N_2O$ | 244.8 | 0.0% | 5% | 9 | 0.00% | 9 |
| 4. Agriculture | $CH_4$、$N_2O$ | 26,546.3 | 2.1% | 18% | 6 | 0.37% | 5 |
| 5. LULUCF | $CO_2$、$CH_4$、$N_2O$ | -81,352.6 | -6.3% | 6% | 8 | -0.37% | 10 |
| 6. Waste | $CO_2$、$CH_4$、$N_2O$ | 24,174.8 | 1.9% | 32% | 2 | 0.59% | 3 |
| Total Emissions | (D) | 1,292,908.9 | 100.0% | (E) 2) **1%** | | | |

## 1.8. General Assessment of the Completeness

In this inventory report, emissions from some categories are not estimated and reported as “NE”. In FY 2006, 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 methodology. Also, some categories, which were previously reported as “NE”, were reviewed within the Committee and newly estimated.

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.

For some categories, dealing with the emission sources of HFCs, PFCs and $SF_6$, activity data are not available from 1990 to 1994.Those categories are therefore reported as “NE” during that period.

# Chapter 2 Trends in GHGs Emissions and Removals

## 2.1. Description and Interpretation of Emission and Removal Trends for Aggregate Greenhouse Gases

### 2.1.1. Greenhouse Gas Emissions and Removals

Total greenhouse gas emission in FY 2007[1] (the sum of emissions of $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, and $SF_6$ converted to $CO_2$ equivalents by multiplying its global warming potential [GWP][2] respectively; excluding for carbon dioxide removals) was 1,374 million tons (in $CO_2$ equivalents), an increase by 13.8% compared to emissions ($CO_2$, $CH_4$, $N_2O$, excluding carbon dioxide removals) in FY 1990. Compared to emissions in the base year under the Kyoto Protocol (FY 1990 for emissions of $CO_2$, $CH_4$, $N_2O$; FY 1995 for emissions of HFCs, PFCs, and $SF_6$), it increased by 9.0%.

It should be noted that actual emissions of HFCs, PFCs, and $SF_6$ in the period from 1990 to 1994, have not been estimated (NE)[3].

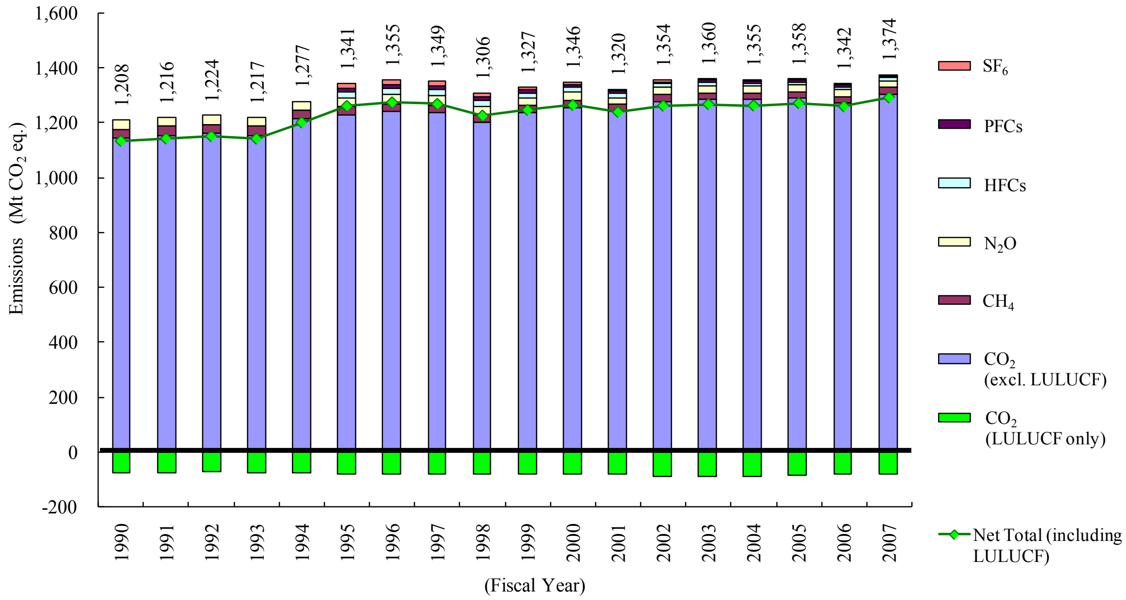


Figure 2-1 Trends in emission and removals of greenhouse gases in Japan

Emissions of carbon dioxide in FY 2007 were 1,304 million tons (without LULUCF), comprising 94.9% of the total. It represents an increase by 14.0% from fiscal 1990, and an increase by 2.6% in comparison with the previous year. Removals of $CO_2$ in FY 2007 were 81.4 million tons[4], equivalent to 5.9% of total annual greenhouse gas emissions. It represents an increase by 9.4% from FY 1990, and a decrease by 0.5% in comparison with the previous year. Emissions in FY 2007 of $CH_4$ (including LULUCF) were 22.6 million tons (in $CO_2$ eq.), comprising 1.6% of total emissions. The

[1] "FY (Fiscal Year)" is used because $CO_2$ is the primary GHGs emissions and estimated on the fiscal year basis; from April of the year to March of the next year. ("CY" stands for "Calendar Year")

[2] Global Warming Potential (GWP): It is the coefficients that indicate degrees of greenhouse gas effects caused by greenhouse gases converted into the proportion of equivalent degrees of $CO_2$. The coefficients are subjected to the *Second National Assessment Report* (1995) issued by the Intergovernmental Panel on Climate Change (IPCC).

[3] Potential emissions are reported in CRF for 1990-1994.

[4] In the inventory submitted under the FCCC, removals by forest planted before 1990 are contained. Therefore, this value do not correspond to 13 Mt indicated in the annex of Decision 16/CMP.1 (Land use, land-use change and forestry) adopted in COP/MOP1.

value represents a reduction by 30.7% from FY 1990 and 1.9% in comparison with the previous year. Emissions in FY 2007 of $N_2O$ (including LULUCF) were 23.8 million tons (in $CO_2$ eq.), comprising 1.7% of total emissions. The value represents a reduction by 25.8% from FY 1990, and a decrease by 3.8% in comparison with the previous year.

Emissions in CY 2007 of HFCs were 13.2 million tons (in $CO_2$ eq.), comprising 1.0% of total emissions. The value represents a reduction by 34.8% on CY 1995, and an increase by 13.7% in comparison with the previous year. Emissions in CY 2007 of PFCs were 6.5 million tons (in $CO_2$ eq.), comprising 0.5% of total emissions. The value represents a reduction by 54.9% from CY 1995, and a decrease by 12.2% in comparison with the previous year. Emissions in CY 2007 of $SF_6$ were 4.4 million tons (in $CO_2$ eq.), comprising 0.3% of total emissions. The value represents a reduction by 74.1% on CY 1995, and a decrease by 14.8% in comparison with the previous year.

Table 2-1 Trends in emissions and removals of greenhouse gas in Japan

| [Mt $CO_2$ eq.] | GWP | Base year of KP | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (excl. LULUCF) | 1 | 1,144.1 | 1,143.2 | 1,152.6 | 1,160.8 | 1,153.6 | 1,213.5 | 1,226.6 | 1,238.9 | 1,234.9 | 1,198.9 | 1,233.9 | 1,254.6 |
| $CO_2$ (incl. LULUCF) | 1 | NA | 1,068.8 | 1,078.4 | 1,087.0 | 1,078.6 | 1,137.8 | 1,147.0 | 1,159.0 | 1,154.7 | 1,118.8 | 1,153.6 | 1,174.0 |
| $CO_2$ (LULUCF only) | 1 | NA | -74.4 | -74.3 | -73.9 | -74.9 | -75.7 | -79.5 | -79.9 | -80.1 | -80.0 | -80.3 | -80.7 |
| $CH_4$ (excl. LULUCF) | 21 | 33.4 | 32.6 | 32.4 | 32.1 | 31.8 | 31.1 | 30.2 | 29.5 | 28.5 | 27.6 | 27.0 | 26.4 |
| $CH_4$ (incl. LULUCF) | 21 | NA | 32.6 | 32.4 | 32.1 | 31.9 | 31.2 | 30.2 | 29.6 | 28.5 | 27.7 | 27.0 | 26.4 |
| $N_2O$ (excl. LULUCF) | 310 | 32.6 | 32.0 | 31.5 | 31.5 | 31.3 | 32.5 | 32.8 | 33.9 | 34.6 | 33.1 | 26.7 | 29.3 |
| $N_2O$ (incl. LULUCF) | 310 | NA | 32.1 | 31.5 | 31.6 | 31.3 | 32.5 | 32.9 | 33.9 | 34.6 | 33.1 | 26.8 | 29.3 |
| HFCs | HFC-134a : 1,300 etc. | 20.2 | NE | NE | NE | NE | NE | 20.3 | 19.9 | 19.9 | 19.4 | 19.9 | 18.8 |
| PFCs | PFC-14 : 6,500 etc. | 14.0 | NE | NE | NE | NE | NE | 14.4 | 14.9 | 16.3 | 13.5 | 10.6 | 9.7 |
| $SF_6$ | 23,900 | 16.9 | NE | NE | NE | NE | NE | 17.0 | 17.5 | 15.0 | 13.6 | 9.3 | 7.3 |
| Gross Total (excluding LULUCF) | | 1,261.3 | 1,207.8 | 1,216.5 | 1,224.5 | 1,216.7 | 1,277.1 | 1,341.2 | 1,354.7 | 1,349.1 | 1,306.2 | 1,327.5 | 1,346.0 |
| Net Total (including LULUCF) | | NA | 1,133.5 | 1,142.3 | 1,150.7 | 1,141.8 | 1,201.4 | 1,261.7 | 1,274.9 | 1,269.0 | 1,226.2 | 1,247.2 | 1,265.4 |

| [Mt $CO_2$ eq.] | GWP | Base year of KP | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Emission increase from the base year of KP | Emission increase from 1990 (2007) | Emission increase from 1995 (2007) | Emission increase from previous year (2007) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ (excl. LULUCF) | 1 | 1,144.1 | 1,238.8 | 1,276.7 | 1,283.9 | 1,282.5 | 1,287.3 | 1,270.2 | 1,303.8 | 14.0% | 14.0% | - | 2.6% |
| $CO_2$ (incl. LULUCF) | 1 | NA | 1,158.0 | 1,185.6 | 1,192.5 | 1,190.9 | 1,201.7 | 1,188.4 | 1,222.4 | - | 14.4% | - | 2.9% |
| $CO_2$ (LULUCF only) | 1 | NA | -80.8 | -91.1 | -91.4 | -91.6 | -85.6 | -81.7 | -81.4 | - | 9.4% | - | -0.5% |
| $CH_4$ (excl. LULUCF) | 21 | 33.4 | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 | 22.6 | -32.3% | -30.7% | - | -1.9% |
| $CH_4$ (incl. LULUCF) | 21 | NA | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 | 22.6 | - | -30.7% | - | -1.9% |
| $N_2O$ (excl. LULUCF) | 310 | 32.6 | 25.8 | 25.5 | 25.2 | 25.3 | 24.8 | 24.7 | 23.8 | -27.1% | -25.6% | - | -3.8% |
| $N_2O$ (incl. LULUCF) | 310 | NA | 25.8 | 25.5 | 25.2 | 25.3 | 24.9 | 24.7 | 23.8 | - | -25.8% | - | -3.8% |
| HFCs | HFC-134a : 1,300 etc. | 20.2 | 16.2 | 13.7 | 13.8 | 10.6 | 10.6 | 11.6 | 13.2 | -34.6% | - | -34.8% | 13.7% |
| PFCs | PFC-14 : 6,500 etc. | 14.0 | 8.1 | 7.5 | 7.3 | 7.5 | 7.1 | 7.4 | 6.5 | -53.8% | - | -54.9% | -12.2% |
| $SF_6$ | 23,900 | 16.9 | 6.0 | 5.7 | 5.4 | 5.3 | 4.6 | 5.1 | 4.4 | -74.1% | - | -74.1% | -14.8% |
| Gross Total (excluding LULUCF) | | 1,261.3 | 1,320.5 | 1,353.7 | 1,359.7 | 1,355.0 | 1,357.8 | 1,342.1 | 1,374.3 | 9.0% | 13.8% | 2.5% | 2.4% |
| Net Total (including LULUCF) | | - | 1,239.7 | 1,262.7 | 1,268.4 | 1,263.4 | 1,272.3 | 1,260.4 | 1,292.9 | - | 14.1% | | 2.6% |

* NA: Not Applicable, NE: Not Estimated

### 2.1.2. $CO_2$ Emissions Per Capita

Total carbon dioxide emissions in fiscal 2007 were 1,304 million tons, giving an emission of 10.20 tons per capita. Compared to fiscal 1990, it represents an increase of 14.0% in total carbon dioxide emissions, and an increase of 10.3% in carbon dioxide emissions per capita. Carbon dioxide emissions compared to the previous year increased by 2.6% in total emissions and by 2.6% per capita.

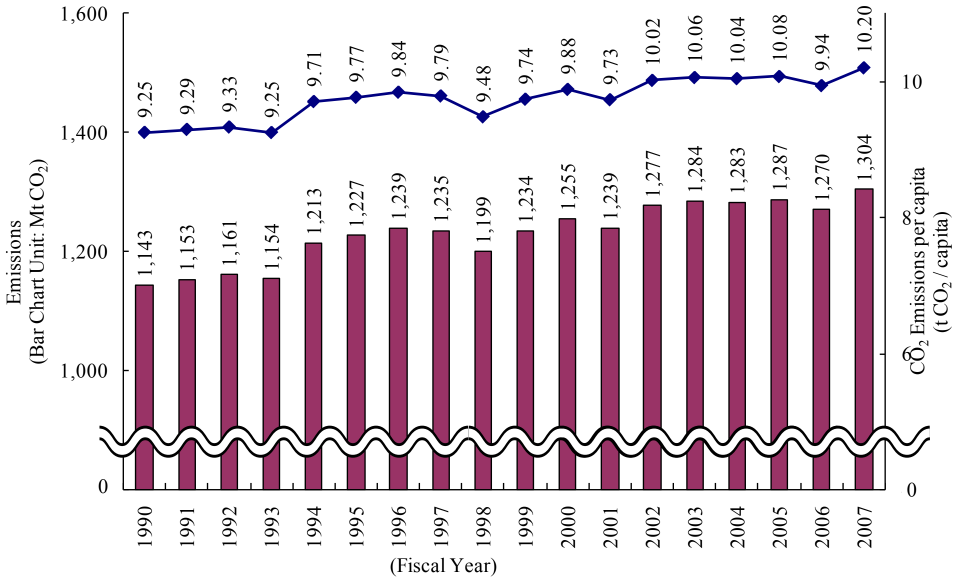


Figure 2-2 Trends in total $CO_2$ emissions and $CO_2$ emissions per capita

Source of population: Ministry of Public Management, Home Affairs, Posts and Telecommunications Japan, *Population Census*

MPMHAPTJ, *Annual Report on Current Population Estimates*

### 2.1.3. $CO_2$ Emissions Per Unit of GDP

Carbon dioxide emissions per unit of GDP in fiscal 2007 were 2.32 tons/million yen, resulting in a decrease by 8.7% since fiscal 1990, and an increase by 0.7% from the previous year.

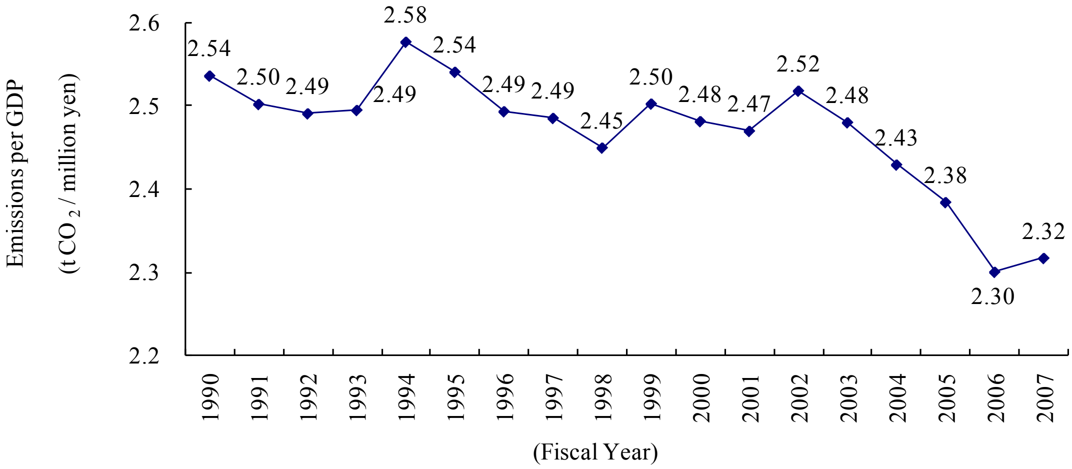


Figure 2-3 Trends in $CO_2$ emissions per unit of GDP

Source of GDP: (Before FY 1993) Energy Conservation Center, *EDMC Handbook of Energy & Economic Statistics in Japan*

(After FY 1994) Cabinet Office, Government of Japan, *Annual Report on National Accounts*

(Real Gross Domestic Product, expenditure approach, chain-linked, chained CY 2000)

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

### 2.2.1. $CO_2$

$CO_2$ emissions in FY 2007 were 1,304 million tons (excluding LULUCF), comprising 94.9% of the total. It represents an increase by 14.0% from FY 1990, and an increase by 2.6% in comparison with the previous year.

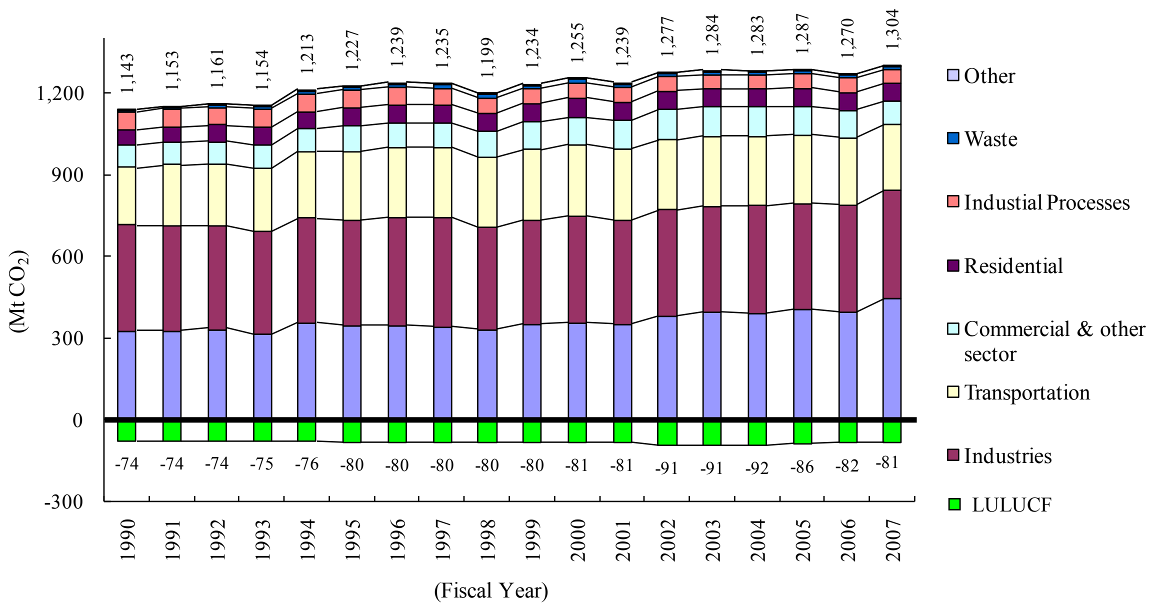


Figure 2-4 Trends in $CO_2$ emissions

The breakdown of $CO_2$ emissions in FY 2007 shows that carbon dioxide emitted in association with the Fuel combustion accounted for 94.7% of the total, carbon dioxide from the Industrial processes accounted for 4.1%, and carbon dioxide from the Waste sector accounted for 1.1%. The Energy industries sector account for 34.4% of emissions of $CO_2$ from the Fuel combustion, making it the single largest source of emissions followed by the Industries sector at 30.3% and the Transport sector at 18.5%.

Fluctuations in emissions by sector show that $CO_2$ emissions from the Fuel combustion in the Energy industries sector, which accounts for about 30% of $CO_2$ emissions, increased by 38.4% compared to FY 1990, and 13.4% compared to the previous year. $CO_2$ emissions from the Fuel combustion in the industries increased by 0.4% compared to FY 1990, and decreased by 0.2% compared to the previous year. $CO_2$ emissions from the Fuel combustion in the transportation increased by 14.5% compared to FY 1990, and decreased by 1.9% compared to the previous year. $CO_2$ emissions from the Fuel combustion in the commercial and other sector increased by 5.1% compared to FY 1990, and decreased by 12.8% compared to the previous year. $CO_2$ emissions from the Fuel combustion in the residential sector increased by 10.8% compared to FY 1990, and decreased by 1.4% compared to the previous year.

Removals of $CO_2$ in FY 2007 were 81.4 million tons[4], equivalent to 5.9% of total annual $CO_2$ emissions. It represents an increase by 9.4% from FY 1990, and a decrease by 0.5% in comparison with the previous year.

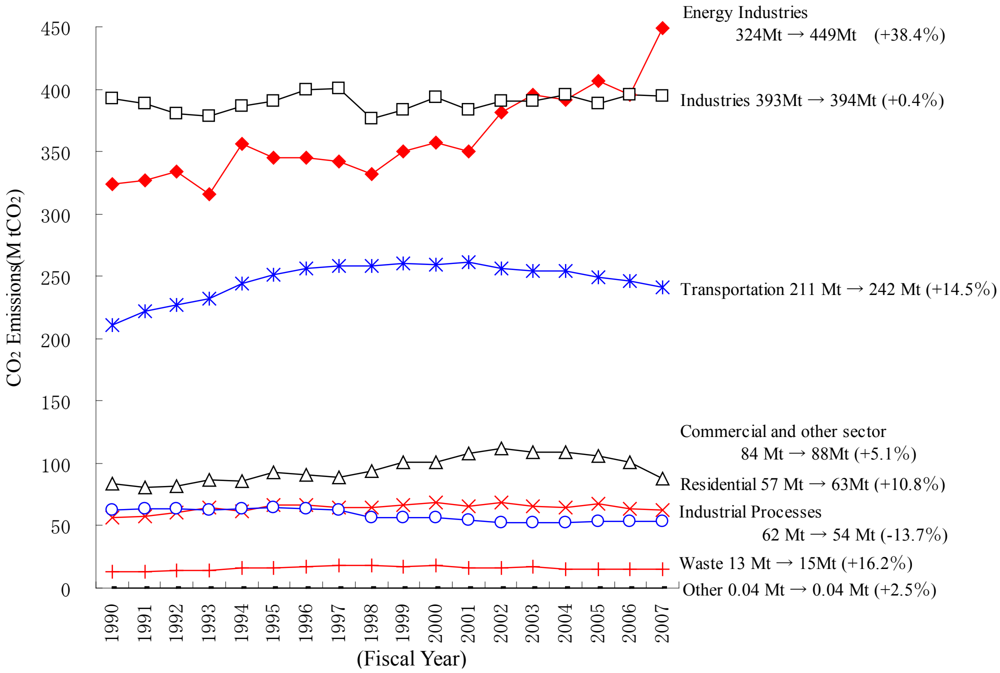


Figure 2-5 Trends in $CO_2$ emissions in each sector
(Figures in brackets indicate relative increase or decrease to the FY 1990 values)

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

[Gg $CO_2$]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 1A. Fuel Combustion | 1,068,019 | 1,145,682 | 1,180,026 | 1,218,738 | 1,201,534 | 1,235,227 |
| Energy Industry | 324,014 | 344,805 | 357,482 | 406,196 | 395,571 | 448,564 |
| Public Electricity & Heat Production | 296,835 | 315,256 | 330,772 | 379,078 | 371,477 | 424,862 |
| Petroleum Refining | 15,893 | 16,956 | 17,285 | 16,436 | 16,090 | 16,015 |
| Manufacture of Solid Fuel and Other Energy | 11,286 | 12,592 | 9,426 | 10,682 | 8,003 | 7,687 |
| Industries | 392,690 | 390,118 | 393,123 | 388,909 | 395,164 | 394,402 |
| Manufacturing Industries & Construction | 371,310 | 370,592 | 377,014 | 375,516 | 381,831 | 381,040 |
| Agriculture, Forestry and Fisheries | 21,380 | 19,526 | 16,109 | 13,393 | 13,333 | 13,362 |
| Transport | 211,054 | 251,161 | 259,204 | 249,534 | 246,335 | 241,587 |
| Civil Aviation | 7,162 | 10,278 | 10,677 | 10,799 | 11,178 | 10,876 |
| Road Transportation | 189,228 | 225,376 | 232,955 | 225,197 | 221,895 | 217,653 |
| Railways | 932 | 819 | 707 | 644 | 645 | 647 |
| Navigation | 13,731 | 14,687 | 14,865 | 12,895 | 12,616 | 12,411 |
| Commercial and Residential | 140,262 | 159,598 | 170,216 | 174,099 | 164,465 | 150,674 |
| Commercial & other sector | 83,593 | 93,277 | 101,258 | 106,324 | 100,814 | 87,896 |
| Residential | 56,668 | 66,320 | 68,958 | 67,775 | 63,650 | 62,777 |
| Other | NO | NO | NO | NO | NO | NO |
| 1B. Fugitive Emissions from Fuel | 37 | 51 | 36 | 38 | 36 | 38 |
| 2. Industrial Processes | 62,269 | 64,223 | 56,839 | 53,858 | 53,862 | 53,730 |
| Mineral Products | 57,399 | 59,340 | 52,412 | 50,431 | 50,464 | 50,219 |
| Chemical Industry | 4,514 | 4,525 | 4,178 | 3,185 | 3,221 | 3,299 |
| Metal Production | 356 | 357 | 248 | 242 | 178 | 212 |
| 5. LULUCF | -74,364 | -79,546 | -80,666 | -85,608 | -81,735 | -81,363 |
| 6. Waste | 12,877 | 16,619 | 17,735 | 14,702 | 14,745 | 14,786 |
| Total (including LULUCF) | 1,068,837 | 1,147,028 | 1,173,970 | 1,201,728 | 1,188,442 | 1,222,419 |
| Total (excluding LULUCF) | 1,143,201 | 1,226,575 | 1,254,636 | 1,287,335 | 1,270,177 | 1,303,781 |

### 2.2.2. $CH_4$

Methane emissions in FY 2007 were 22.6 million tons (in $CO_2$ eq.), comprising 1.6% of total emissions. The value represents a reduction by 30.7% from FY 1990 and 1.9% in comparison with the previous year. The reduction from FY 1990 is mainly a result of a reduction of waste sector's emission (e.g. SWDS) decreased by 46% compared to FY 1990.

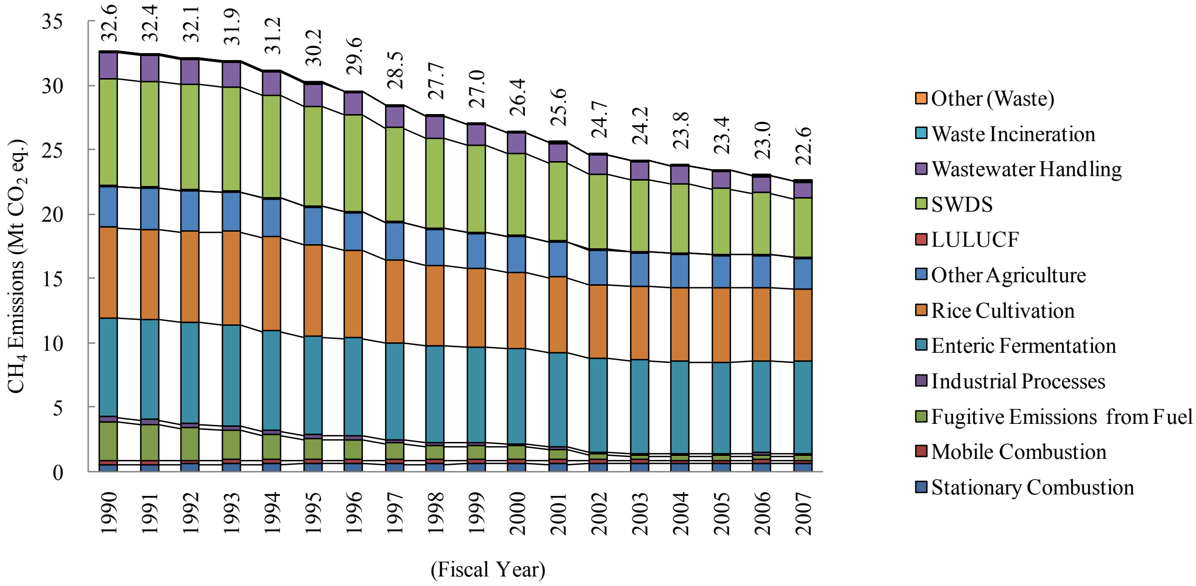


Figure 2-6 Trends in $CH_4$ emissions

The breakdown of methane emissions in FY 2007 shows that methane emitted from enteric fermentation in livestock accounted for 31% of the total, making it the single largest source of emissions. It is followed by methane emissions from rice cultivation at 25%, and methane emissions from SWDS (Solid Waste Disposal Site) at 20%.

Table 2-3 Trends in $CH_4$ emissions

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 1A. Fuel Combustion | 881 | 955 | 956 | 892 | 917 | 869 |
| 1A1. Energy Industries | 30 | 34 | 44 | 43 | 45 | 50 |
| 1A2. Industries | 347 | 358 | 345 | 358 | 369 | 369 |
| 1A3. Transport | 297 | 308 | 298 | 238 | 223 | 209 |
| 1A4. Residential / Institutional | 207 | 255 | 269 | 253 | 281 | 241 |
| 1B. Fugitive Emissions from Fuels | 3,037 | 1,610 | 1,043 | 396 | 409 | 416 |
| 1B1. Solid Fuels | 2,806 | 1,345 | 769 | 74 | 68 | 51 |
| 1B2. Oil & Natural Gas | 231 | 265 | 274 | 322 | 340 | 365 |
| 2. Industrial Processes | 358 | 322 | 181 | 134 | 133 | 134 |
| 4. Agriculture | 17,912 | 17,756 | 16,127 | 15,477 | 15,399 | 15,272 |
| 4A. Enteric Fermentation | 7,674 | 7,605 | 7,374 | 7,087 | 7,105 | 7,121 |
| 4B. Manure Management | 3,105 | 2,903 | 2,688 | 2,513 | 2,448 | 2,394 |
| 4C. Rice Cultivation | 7,003 | 7,127 | 5,956 | 5,775 | 5,743 | 5,654 |
| 4F. Field Burning of Agricultural | 130 | 121 | 109 | 102 | 103 | 103 |
| 5. LULUCF | 8 | 9 | 8 | 9 | 2 | 2 |
| 6. Waste | 10,434 | 9,576 | 8,058 | 6,524 | 6,180 | 5,913 |
| 6A. SWDS | 8,286 | 7,689 | 6,394 | 5,094 | 4,784 | 4,517 |
| 6B. Wastewater Handling | 2,121 | 1,861 | 1,637 | 1,406 | 1,369 | 1,369 |
| 6C. Waste Incineration | 13 | 15 | 13 | 10 | 10 | 10 |
| 6D. Other (Waste) | 14 | 11 | 13 | 14 | 17 | 17 |
| Total (including LULUCF) | 32,631 | 30,229 | 26,372 | 23,430 | 23,039 | 22,606 |
| Total (excluding LULUCF) | 32,622 | 30,220 | 26,365 | 23,421 | 23,037 | 22,604 |

### 2.2.3. $N_2O$

$N_2O$ emissions in FY 2007 were 23.8 million tons (in $CO_2$ eq.), comprising 1.7% of total emissions. The value represents a reduction by 25.8% from FY 1990, and a decrease by 3.8% in comparison with the previous year. The reduction from FY 1990 is mainly a result of a reduction of Industrial processes sector's emission (e.g. adipic acid production) decreased by 90% compared to FY 1990. In March 1999, $N_2O$ abatement equipment came on stream in the adipic acid production plant, causing a sharp decline in emissions from the Industrial processes during the period from FY 1998 to FY 1999. In FY 2000, $N_2O$ emissions increased because of a decrease in operational rate of the abatement equipment. In 2001, $N_2O$ emissions decreased with resuming the normal operation of the equipment.

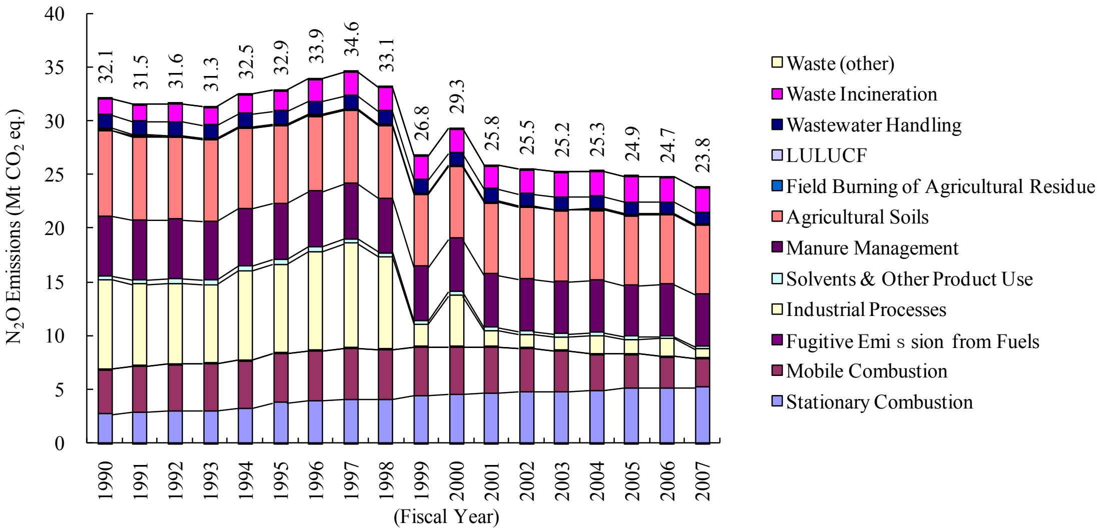


Figure 2-7 Trends in $N_2O$ emissions

The breakdown of nitrous oxide emissions in FY 2007 shows that emissions from agricultural soils for 27% of the total, making it the single largest source of emissions. It is followed by emissions from fuel combustion in stationary sources accounted at 22%, and emissions from manure management of 20%.

Table 2-4 Trends in $N_2O$ emissions

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 1A. Fuel Combustion | 6,923 | 8,381 | 9,015 | 8,331 | 8,089 | 7,942 |
| 1A1. Energy Industries | 920 | 1,455 | 1,765 | 1,982 | 1,980 | 2,064 |
| 1A2. Industries | 1,527 | 1,940 | 2,327 | 2,771 | 2,790 | 2,778 |
| 1A3. Transport | 4,204 | 4,650 | 4,561 | 3,221 | 2,974 | 2,783 |
| 1A4. Residential / Institutional | 272 | 336 | 362 | 357 | 345 | 316 |
| 1B. Fugitive Emissions from Fuels | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| 2. Industrial Processes | 8,267 | 8,213 | 4,690 | 1,300 | 1,625 | 860 |
| 3. Solvent & Other Product Use | 287 | 438 | 341 | 266 | 245 | 245 |
| 4. Agriculture | 13,696 | 12,552 | 11,759 | 11,355 | 11,311 | 11,274 |
| 4B. Manure Management | 5,661 | 5,246 | 4,984 | 4,849 | 4,854 | 4,861 |
| 4D. Agricultural Soils | 7,931 | 7,218 | 6,694 | 6,433 | 6,382 | 6,337 |
| 4F. Field Burning of Agricultural | 104 | 89 | 81 | 73 | 75 | 76 |
| 5. LULUCF | 69 | 42 | 21 | 11 | 9 | 8 |
| 6. Waste | 2,820 | 3,260 | 3,470 | 3,594 | 3,470 | 3,470 |
| 6B. Wastewater Handling | 1,290 | 1,247 | 1,214 | 1,169 | 1,159 | 1,159 |
| 6C. Waste Incineration | 1,518 | 2,003 | 2,245 | 2,413 | 2,296 | 2,296 |
| 6D. Waste (other) | 13 | 10 | 12 | 13 | 15 | 15 |
| Total (including LULUCF) | 32,063 | 32,885 | 29,297 | 24,857 | 24,748 | 23,800 |
| Total (excluding LULUCF) | 31,994 | 32,843 | 29,276 | 24,846 | 24,739 | 23,792 |

### 2.2.4. HFCs

Emissions of HFCs in 2007[5] were 13.2 million tons (in $CO_2$ eq.), comprising 1.0% of total emissions. The value represents a reduction by 34.8% on CY 1995, and an increase by 13.7% in comparison with the previous year. The reduction from CY 1995 is mainly a result of a reduction of HFC-23, a by-product of HCFF-22, decreased by 99% compared to CY 1995.

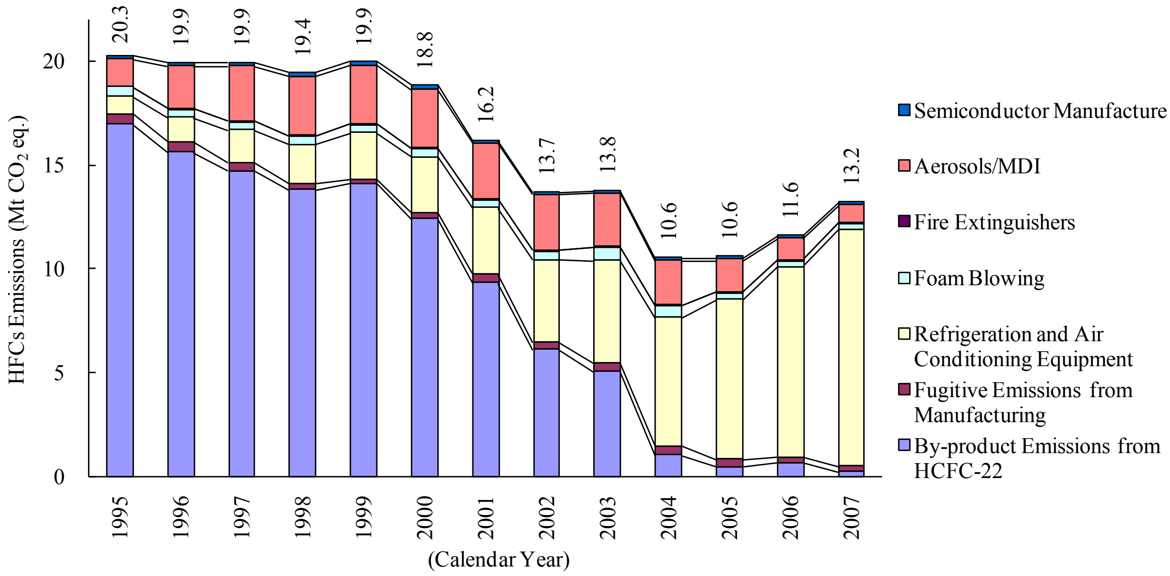


Figure 2-8 Trends in HFCs emissions

The breakdown of HFCs emissions in 2007 shows that emissions from refrigerants of refrigeration and air conditioning equipment accounted for 86% of the total, followed by emissions from aerosols / MDI at 6%.

Table 2-5 Trends in HFCs emissions

[Gg $CO_2$eq.]

| Category | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| 2E. Productions of F-gas | 17,445 | 12,660 | 816 | 938 | 498 |
| 2E1. By-product Emissions from Production of HCFC-22 | 16,965 | 12,402 | 463 | 657 | 218 |
| 2E2. Fugitive Emissions | 480 | 258 | 353 | 281 | 280 |
| 2F. Consumption of F-gas | 2,815 | 6,141 | 9,785 | 10,685 | 12,713 |
| 2F1. Refrigeration and Air Conditioning Equipment | 840 | 2,688 | 7,703 | 9,160 | 11,375 |
| 2F2. Foam Blowing | 452 | 440 | 364 | 310 | 317 |
| 2F2. Fire Extinguishers | NO | 4 | 6 | 6 | 6 |
| 2F4. Aerosols/MDI | 1,365 | 2,834 | 1,572 | 1,057 | 850 |
| 2F7. Semiconductor Manufacture | 158 | 174 | 139 | 152 | 164 |
| 2F9. Other | NA | NA | NA | NA | NA |
| Total | 20,261 | 18,800 | 10,601 | 11,623 | 13,210 |

[5] Emissions of calendar year basis are adopted for HFCs, PFCs and $SF_6$.

### 2.2.5. PFCs

PFCs emissions in 2007 were 6.5 million tons (in $CO_2$ eq.), comprising 0.5% of total emissions. The value represents a reduction by 54.9% from CY 1995, and a decrease by 12.2% in comparison with the previous year. The reduction from CY 1995 is mainly a result of an emission reduction of solvents decreased by 81% compared to CY 1995.

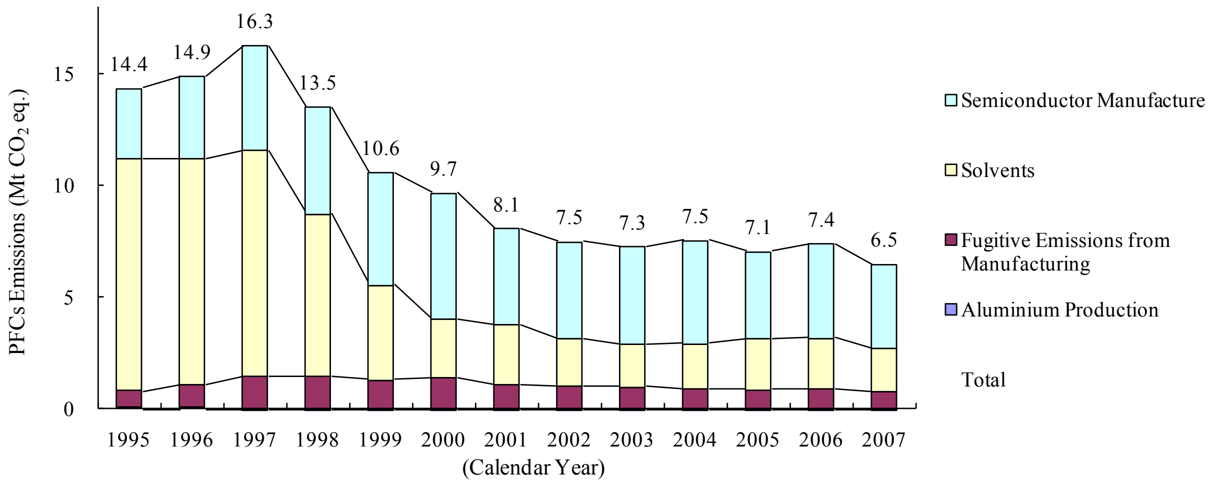


Figure 2-9 Trends in PFCs emissions

The breakdown of PFCs emissions in 2007 shows that emission from semiconductor manufacture accounted for 58% of the total, followed by emissions from solvents in washing metals etc. at 30%, and fugitive emissions from manufacturing at 12%.

Table 2-6 Trends in PFCs emissions

[Gg $CO_2$eq.]

| Category | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| 2C3. Aluminium Production | 70 | 18 | 15 | 15 | 15 |
| 2E2. Fugitive Emissions | 763 | 1,359 | 837 | 879 | 783 |
| 2F. Consumption of F-gas | 13,531 | 8,288 | 6,206 | 6,491 | 5,686 |
| 2F5. Solvents | 10,382 | 2,649 | 2,305 | 2,286 | 1,944 |
| 2F7. Semiconductor | 3,149 | 5,639 | 3,901 | 4,205 | 3,741 |
| Total | 14,363 | 9,665 | 7,058 | 7,385 | 6,483 |

### 2.2.6. $SF_6$

Emissions of $SF_6$ in 2007 were 4.4 million tons (in $CO_2$ eq.), comprising 0.3% of total emissions. The value represents a reduction by 74.1% on CY 1995, and 14.8% in comparison with the previous year. The reduction from CY 1995 is mainly a result of an emission reduction of electrical equipment decreased by 92% compared to CY 1995.

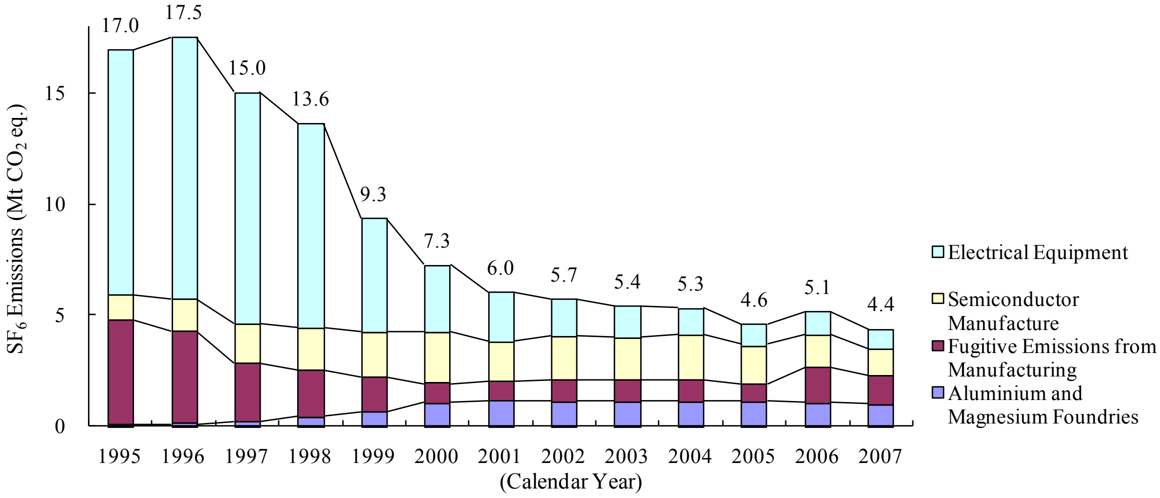


Figure 2-10 Trends in $SF_6$ emissions

The breakdown of $SF_6$ emissions in 2007 shows that emissions from the fugitive emissions accounted for 29%, followed by emissions from semiconductor manufacture at 27%, and emissions from Magnesium Foundries at 23%.

Table 2-7 Trends in $SF_6$ emissions

[Gg $CO_2$eq.]

| Category | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| 2C4. $SF_6$ Used in Aluminium and Magnesium Found | 120 | 1,028 | 1,114 | 1,046 | 996 |
| 2E2. Fugitive Emissions | 4,708 | 932 | 789 | 1,648 | 1,270 |
| 2F. Consumption of F-gas | 12,134 | 5,295 | 2,678 | 2,453 | 2,118 |
| 2F7. Semiconductor Manufacture | 1,129 | 2,245 | 1,736 | 1,440 | 1,196 |
| 2F8. Electrical Equipment | 11,005 | 3,050 | 943 | 1,014 | 922 |
| Total | 16,962 | 7,255 | 4,582 | 5,147 | 4,385 |

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

The breakdown of emissions and removals of greenhouse gases in FY 2007 by sector[6] shows that the Energy sector accounted for 90.6%, followed by Industrial processes at 5.7%, Solvents and other product use at 0.02%, Agriculture at 1.9% and Waste at 1.8% of total annual greenhouse gas emissions.

Removals by Land Use, Land Use change and forestry in FY 2007 were equivalent to 5.9% of total annual greenhouse gas emissions.

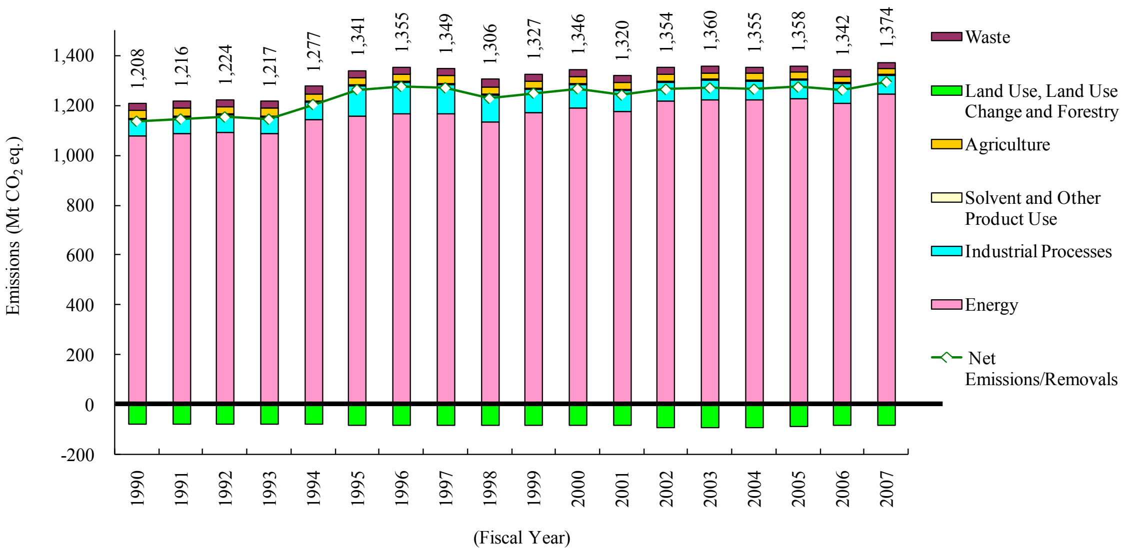


Figure 2-11 Trends in emissions and removals of greenhouse gases in each category

Table 2-8 Trends in emissions and removals of greenhouse gases in each category

| [Mt $CO_2$ eq.] | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| Energy | 1,078.9 | 1,086.8 | 1,094.2 | 1,087.7 | 1,143.8 | 1,156.7 | 1,169.0 | 1,166.0 | 1,135.8 | 1,171.2 |
| Industrial Processes | 70.9 | 71.7 | 71.3 | 70.3 | 72.6 | 124.3 | 125.9 | 123.5 | 111.6 | 98.3 |
| 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 |
| Agriculture | 31.6 | 31.5 | 31.4 | 31.3 | 30.9 | 30.3 | 29.6 | 29.0 | 28.6 | 28.1 |
| Land Use, Land Use Change and Forestry | -74.3 | -74.2 | -73.8 | -74.9 | -75.6 | -79.5 | -79.8 | -80.1 | -80.0 | -80.3 |
| Waste | 26.1 | 26.1 | 27.2 | 26.9 | 29.3 | 29.5 | 29.8 | 30.2 | 29.9 | 29.5 |
| Net Emissions/Removals | 1,133.5 | 1,142.3 | 1,150.7 | 1,141.8 | 1,201.4 | 1,261.7 | 1,274.9 | 1,269.0 | 1,226.2 | 1,247.2 |
| Emissions | 1,207.8 | 1,216.5 | 1,224.5 | 1,216.7 | 1,277.1 | 1,341.2 | 1,354.7 | 1,349.1 | 1,306.2 | 1,327.5 |

| [Mt $CO_2$ eq.] | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Energy | 1,191.1 | 1,178.4 | 1,218.4 | 1,224.2 | 1,224.2 | 1,228.4 | 1,211.0 | 1,244.5 |
| Industrial Processes | 97.4 | 86.6 | 80.9 | 80.0 | 77.8 | 77.5 | 79.8 | 78.8 |
| Solvent and Other Product Use | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 |
| Agriculture | 27.9 | 27.6 | 27.4 | 27.2 | 27.0 | 26.8 | 26.7 | 26.5 |
| Land Use, Land Use Change and Forestry | -80.6 | -80.8 | -91.0 | -91.3 | -91.6 | -85.6 | -81.7 | -81.4 |
| Waste | 29.3 | 27.6 | 26.8 | 28.0 | 25.8 | 24.8 | 24.4 | 24.2 |
| Net Emissions/Removals | 1,265.4 | 1,239.7 | 1,262.7 | 1,268.4 | 1,263.4 | 1,272.3 | 1,260.4 | 1,292.9 |
| Emissions | 1,346.0 | 1,320.5 | 1,353.7 | 1,359.7 | 1,355.0 | 1,357.8 | 1,342.1 | 1,374.3 |

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

### 2.3.1. Energy

Emissions from the Energy sector in FY 2007 were 1,244 million tons (in $CO_2$ equivalents), an increase by 15.3% compared to FY 1990, and an increase by 2.8% in comparison with the previous year.

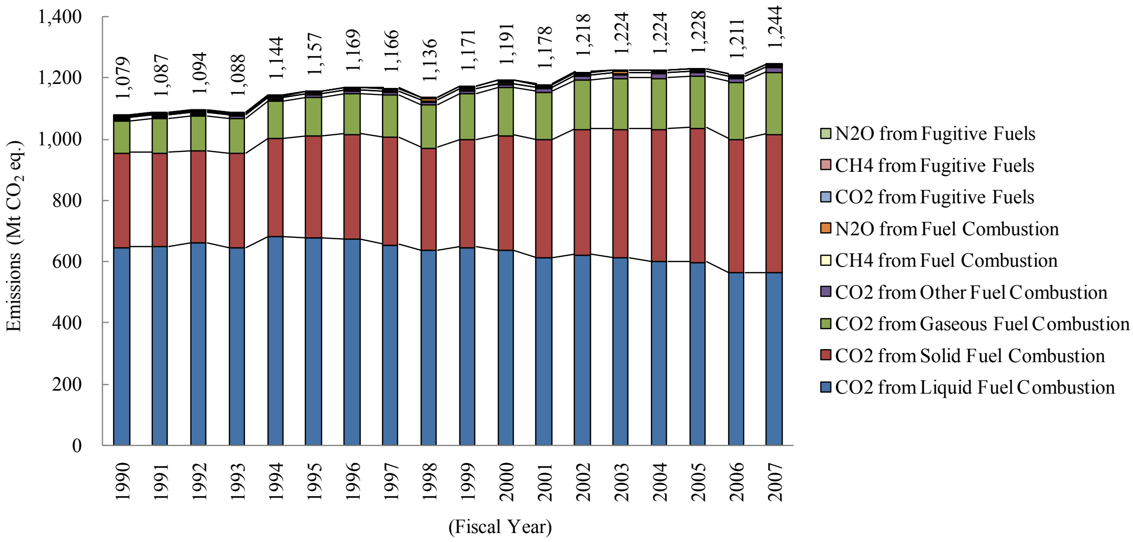


Figure 2-12 Trends in GHGs emissions from the Energy sector

The breakdown of emissions of greenhouse gases from the Energy sector in FY 2007 shows that $CO_2$ emissions from liquid fuel account for 45%, making it the single largest source of emissions followed by the $CO_2$ emissions from solid fuel at 36% and the $CO_2$ emissions from Gaseous fuel at 16%.

Table 2-9 Trends in GHGs emissions from the Energy sector

[Gg $CO_2$eq.]

| Source Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 1A. Fuel Combustion | 1,075,824 | 1,155,018 | 1,189,997 | 1,227,960 | 1,210,540 | 1,244,039 |
| Liquid Euel $CO_2$ | 646,223 | 677,349 | 635,121 | 598,218 | 562,478 | 564,064 |
| Solid Fuel $CO_2$ | 308,620 | 331,721 | 376,537 | 438,247 | 437,025 | 451,893 |
| Gaseous Fuel $CO_2$ | 104,301 | 126,198 | 155,261 | 166,837 | 186,389 | 203,287 |
| Other Fuels (Waste) | 8,875 | 10,415 | 13,108 | 15,436 | 15,643 | 15,983 |
| $CH_4$ | 881 | 955 | 956 | 892 | 917 | 869 |
| $N_2O$ | 6,923 | 8,381 | 9,015 | 8,331 | 8,089 | 7,942 |
| 1B. Fugitive Emissions from Fuel | 3,074 | 1,661 | 1,079 | 433 | 445 | 454 |
| $CO_2$ | 37 | 51 | 36 | 38 | 36 | 38 |
| $CH_4$ | 3,037 | 1,610 | 1,043 | 396 | 409 | 416 |
| $N_2O$ | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Total | 1,078,898 | 1,156,679 | 1,191,076 | 1,228,394 | 1,210,984 | 1,244,493 |

### 2.3.2. Industrial Processes

Emissions from the Industrial processes sector in FY 2007 were 78.8 million tons (in $CO_2$ equivalents), an increase by 11.2% compared to FY 1990, and a decrease by 1.2% in comparison with the previous year.

It should be noted that actual emissions of HFCs, PFCs, and sulfur hexafluoride have not been estimated (NE) through 1990 to 1994.

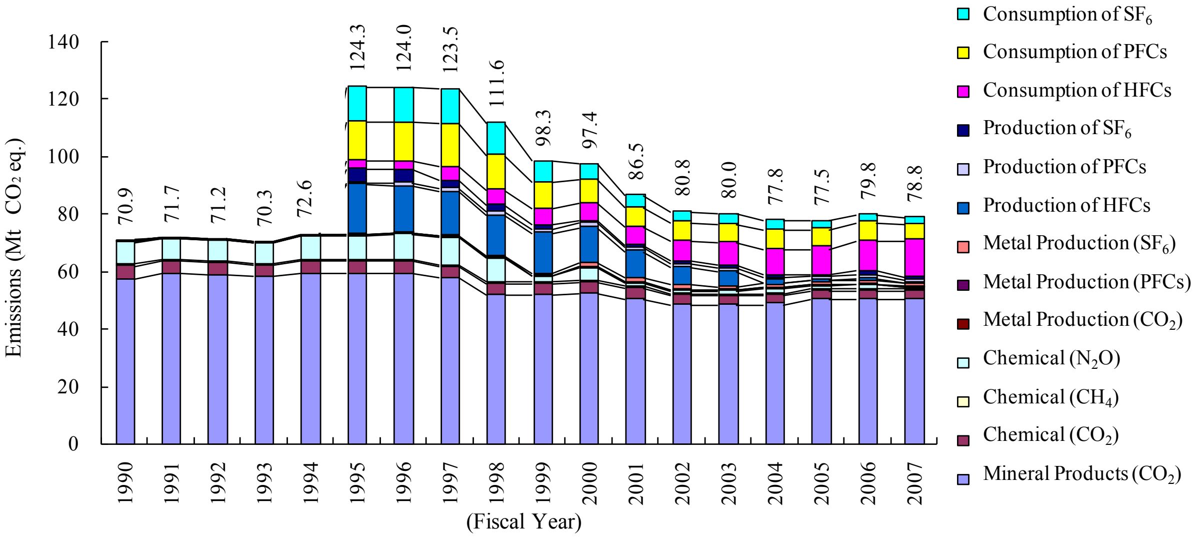


Figure 2-13 Trends in GHGs emissions from the Industrial processes sector

The breakdown of emissions of greenhouse gases from the Industrial processes sector in FY 2007 shows that emissions from mineral products, such as $CO_2$ emissions from the limestone in cement production account for 64%, making it the single largest source of emissions followed by the emissions from the consumption of HFCs at 16% and the consumption of PFCs at 7%.

Table 2-10 Trends in GHGs emissions in the Industrial processes sector

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 2A. Mineral Products ($CO_2$ | 57,399 | 59,340 | 52,412 | 50,431 | 50,464 | 50,219 |
| 2B. Chemical Industry | 13,119 | 13,043 | 9,032 | 4,602 | 4,962 | 4,276 |
| $CO_2$ | 4,514 | 4,525 | 4,178 | 3,185 | 3,221 | 3,299 |
| $CH_4$ | 338 | 304 | 164 | 117 | 116 | 117 |
| $N_2O$ | 8,267 | 8,213 | 4,690 | 1,300 | 1,625 | 860 |
| 2C. Metal Production | 356 | 564 | 1,311 | 1,388 | 1,255 | 1,240 |
| $CO_2$ | 356 | 357 | 248 | 242 | 178 | 212 |
| PFCs | NE | 70 | 18 | 15 | 15 | 15 |
| $SF_6$ | NE | 120 | 1,028 | 1,114 | 1,046 | 996 |
| 2E. Production of F-gas | NE | 22,916 | 14,951 | 2,443 | 3,466 | 2,551 |
| HFCs | NE | 17,445 | 12,660 | 816 | 938 | 498 |
| PFCs | NE | 763 | 1,359 | 837 | 879 | 783 |
| $SF_6$ | NE | 4,708 | 932 | 789 | 1,648 | 1,270 |
| 2F. Consumption of F-gas | NE | 28,480 | 19,724 | 18,669 | 19,629 | 20,517 |
| HFCs | NE | 2,815 | 6,141 | 9,785 | 10,685 | 12,713 |
| PFCs | NE | 13,531 | 8,288 | 6,206 | 6,491 | 5,686 |
| $SF_6$ | NE | 12,134 | 5,295 | 2,678 | 2,453 | 2,118 |
| Total | 70,874 | 124,344 | 97,430 | 77,533 | 79,775 | 78,802 |

### 2.3.3. Solvent and Other Product Use

Emissions from the Solvents and other product use in FY 2007 were 245 thousand tons (in $CO_2$ equivalents), a decrease by 14.7% on FY 1990, and a same in comparison with the previous year. The only substance included in calculations in this sector is laughing gas (nitrous oxide) used as a general anesthetic in hospitals.

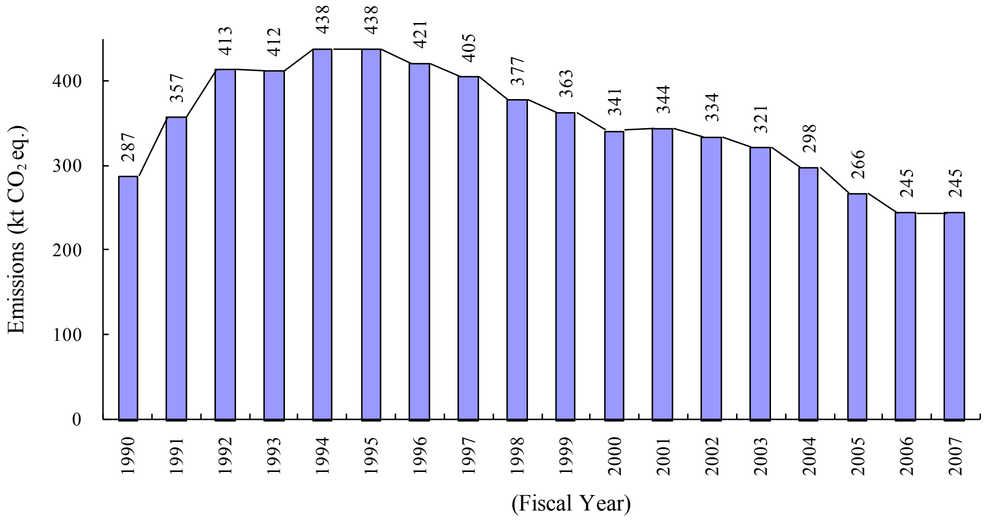


Figure 2-14 Trends in GHGs emissions from the Solvent and other product use sector

### 2.3.4. Agriculture

Emissions from the Agriculture in FY 2007 were 26.5 million tons (in $CO_2$ equivalents), a decrease by 16.0% compared to FY 1990, and by 0.6% in comparison with the previous year.

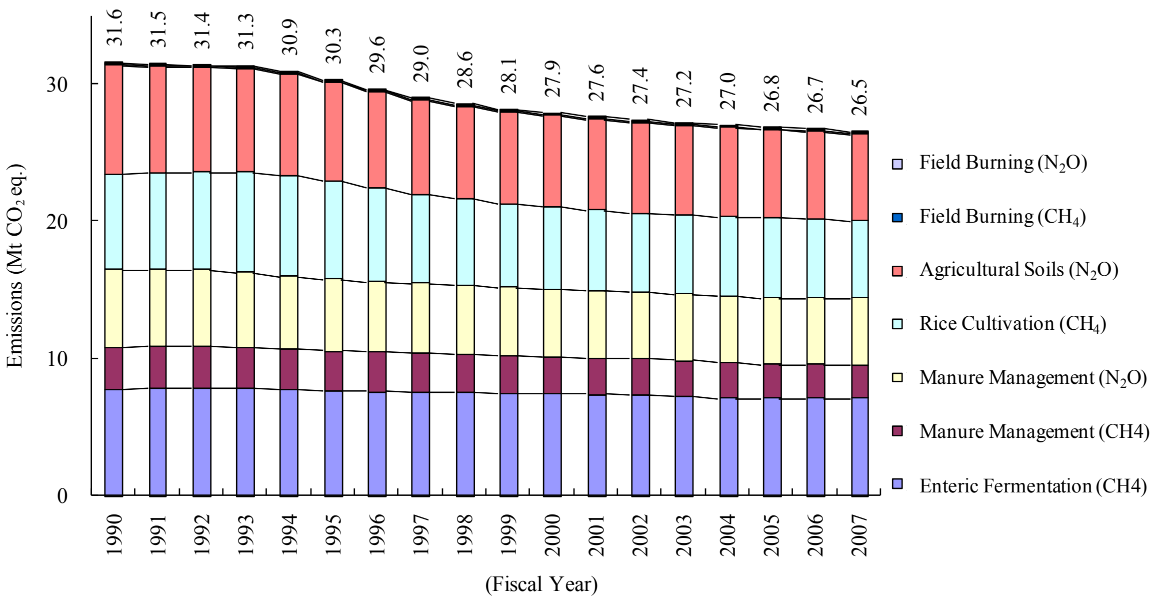


Figure 2-15 Trends in GHGs emissions from the Agriculture sector

The breakdown of emissions of greenhouse gases from the Agriculture in FY 2007 shows that $CH_4$ emissions from enteric fermentation accounts for 27%, making it the single largest source followed by $N_2O$ emissions from agricultural soils due to the nitrogen-based fertilizers at 24%, and $CH_4$ emissions from rice cultivation at 21%.

Table 2-11 Trends in GHGs emissions from the Agriculture sector

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 4A. Enteric Fermentation($CH_4$) | 7,674 | 7,605 | 7,374 | 7,087 | 7,105 | 7,121 |
| 4B. Manure Management | 8,766 | 8,149 | 7,671 | 7,361 | 7,303 | 7,255 |
| $CH_4$ | 3,105 | 2,903 | 2,688 | 2,513 | 2,448 | 2,394 |
| $N_2O$ | 5,661 | 5,246 | 4,984 | 4,849 | 4,854 | 4,861 |
| 4C. Rice Cultivation($CH_4$) | 7,003 | 7,127 | 5,956 | 5,775 | 5,743 | 5,654 |
| 4D. Agricultural Soils ($N_2O$) | 7,931 | 7,218 | 6,694 | 6,433 | 6,382 | 6,337 |
| 4F. Field Burning of Agricultural Residues | 234 | 210 | 190 | 175 | 178 | 179 |
| $CH_4$ | 130 | 121 | 109 | 102 | 103 | 103 |
| $N_2O$ | 104 | 89 | 81 | 73 | 75 | 76 |
| Total | 31,608 | 30,308 | 27,886 | 26,832 | 26,710 | 26,546 |

### 2.3.5. Land Use, Land Use Change and Forestry

Net Removals (including $CH_4$ and $N_2O$ emissions) in the Land Use, Land Use Change and Forestry (LULUCF) in fiscal 2007 was 81.4 million tons (in $CO_2$ equivalents), an increase by 9.5% on FY 1990, and a decrease by 0.5% in comparison with the previous year.

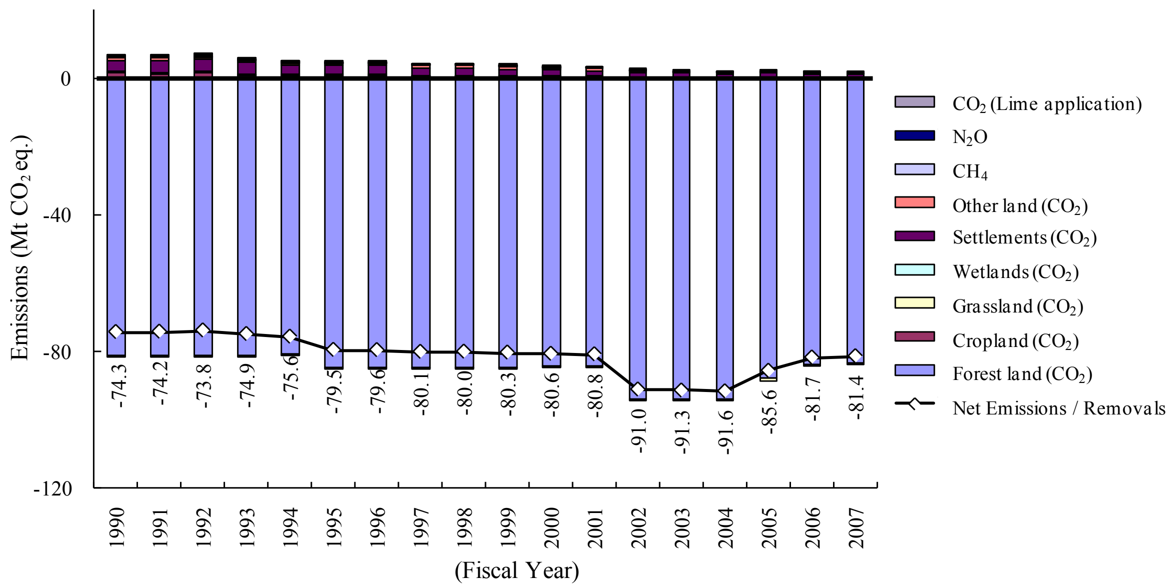


Figure 2-16 Trends in emissions and removals of GHGs from the LULUCF sector

The breakdown of emissions and removals of greenhouse gases from the LULUCF in FY 2007 shows that $CO_2$ removals to forest was 82.9 million tons, accounting for 102% of total net removals of LULUCF sector.

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

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 5A. Forest land | -80,769 | -84,355 | -84,042 | -87,494 | -83,390 | -82,865 |
| $CO_2$ | -80,778 | -84,365 | -84,050 | -87,504 | -83,392 | -82,867 |
| $CH_4$ | 8 | 9 | 8 | 9 | 2 | 2 |
| $N_2O$ | 0.8 | 0.9 | 0.8 | 0.9 | 0.2 | 0.2 |
| 5B. Cropland | 2,126 | 1,015 | 535 | 269 | 266 | 273 |
| $CO_2$ | 2,058 | 974 | 514 | 259 | 257 | 265 |
| $CH_4$ | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO | NE,NO |
| $N_2O$ | 68 | 41 | 20 | 10 | 9 | 8 |
| 5C. Grassland | -516 | -401 | -460 | -593 | -621 | -615 |
| $CO_2$ | -516 | -401 | -460 | -593 | -621 | -615 |
| $CH_4$ | 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 |
| 5D. Wetlands | 292 | 355 | 407 | 142 | 187 | 167 |
| $CO_2$ | 292 | 355 | 407 | 142 | 187 | 167 |
| $CH_4$ | 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 |
| 5E. Settlements | 3,073 | 2,583 | 1,663 | 1,261 | 924 | 849 |
| $CO_2$ | 3,073 | 2,583 | 1,663 | 1,261 | 924 | 849 |
| $CH_4$ | 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 |
| 5F. Other land | 957 | 1,004 | 927 | 597 | 680 | 608 |
| $CO_2$ | 957 | 1,004 | 927 | 597 | 680 | 608 |
| $CH_4$ | 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 |
| 5G. Other | 550 | 303 | 333 | 231 | 230 | 230 |
| $CO_2$ | 550 | 303 | 333 | 231 | 230 | 230 |
| Total | -74,287 | -79,496 | -80,637 | -85,588 | -81,723 | -81,353 |

### 2.3.6. Waste

Emissions from the Waste in FY 2007 were 24.2 million tons (in $CO_2$ equivalents), a decrease by 7.5% compared to FY 1990, and a decrease by 0.9% in comparison with the previous year[7].

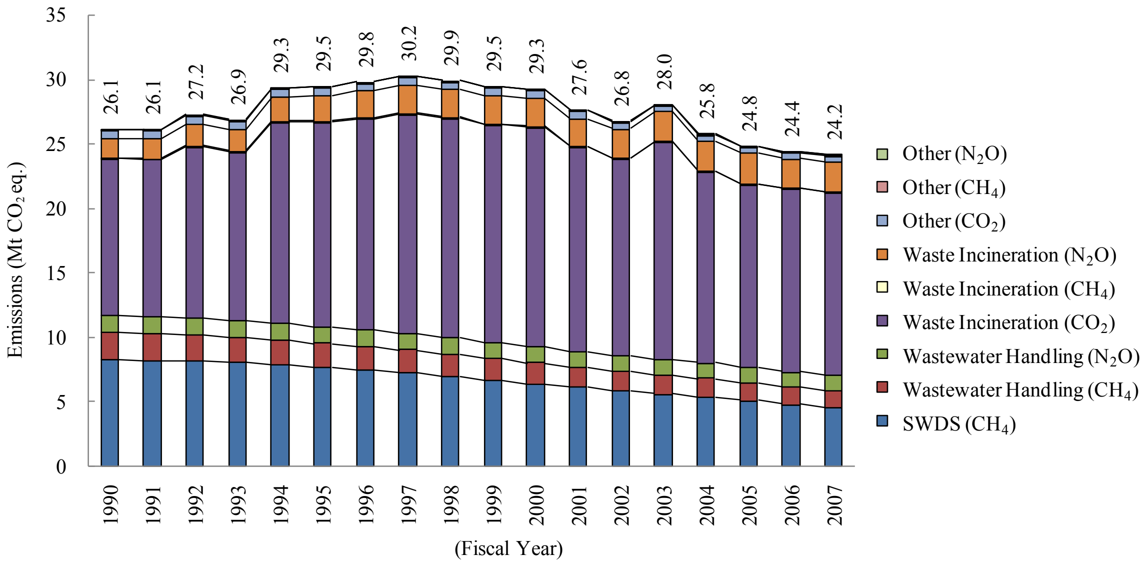


Figure 2-17 Trends in GHGs emissions from the Waste sector

[7] Starting with the 2009 inventory report, the reporting categories which fall under the "Emissions from Waste Used as Energy and the Incineration of Waste Accompanied by Energy Recovery" are moved from Incineration of Waste (Category 6.C.) to Fuel Combustion (Category 1.A.).

The breakdown of GHGs emissions from the Waste in FY 2007 shows that $CO_2$ emissions from waste derived from petrochemicals such as waste plastics and waste oil incineration account for 59%, making it the single largest source of emissions. It is followed by $CH_4$ emissions from solid waste disposal sites at 19%, and $N_2O$ emissions from combustion of waste (including waste products derived from substances other than fossil fuels) at 10%.

Table 2-13 Trends in GHGs emissions from the Waste sector

[Gg $CO_2$eq.]

| Category | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| 6A. SWDS ($CH_4$) | 8,286 | 7,689 | 6,394 | 5,094 | 4,784 | 4,517 |
| 6B. Wastewater Handling | 3,410 | 3,108 | 2,851 | 2,575 | 2,528 | 2,528 |
| $CH_4$ | 2,121 | 1,861 | 1,637 | 1,406 | 1,369 | 1,369 |
| $N_2O$ | 1,290 | 1,247 | 1,214 | 1,169 | 1,159 | 1,159 |
| 6C. Waste Incineration | 13,705 | 17,968 | 19,337 | 16,617 | 16,528 | 16,533 |
| $CO_2$ | 12,174 | 15,951 | 17,079 | 14,195 | 14,222 | 14,227 |
| $CH_4$ | 13 | 15 | 13 | 10 | 10 | 10 |
| $N_2O$ | 1,518 | 2,003 | 2,245 | 2,413 | 2,296 | 2,296 |
| 6D. Other | 730 | 689 | 681 | 534 | 554 | 591 |
| $CO_2$ | 703 | 668 | 656 | 507 | 522 | 560 |
| $CH_4$ | 14 | 11 | 13 | 14 | 17 | 17 |
| $N_2O$ | 13 | 10 | 12 | 13 | 15 | 15 |
| Total | 26,131 | 29,455 | 29,263 | 24,819 | 24,394 | 24,169 |

## 2.4. Description and Interpretation of Emission Trends for Indirect Greenhouse Gases and $SO_2$

Under UNFCCC, it is required to report emissions of indirect greenhouse gases ($NO_X$, CO and NMVOC) and $SO_2$, other than 6 types of greenhouse gases ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs and $SF_6$) which are controlled by the Kyoto Protocol. Emission trends of these gases are indicated below.

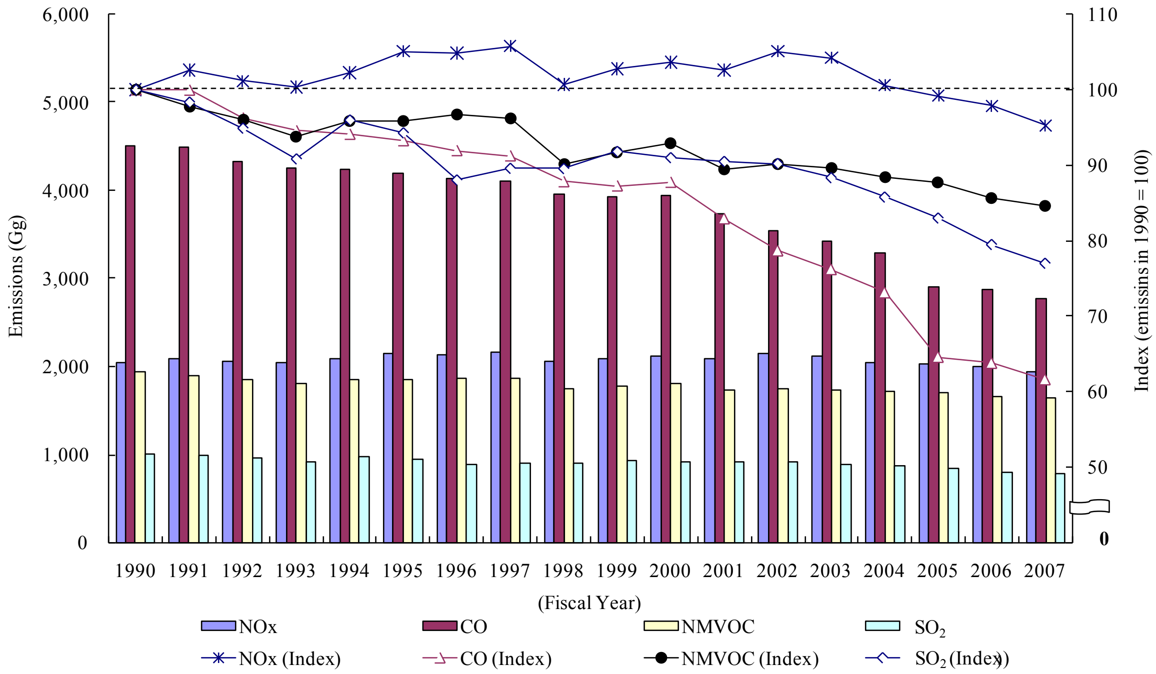


Figure 2-18 Trends in Emissions of Indirect Greenhouse Gases and $SO_2$

Nitrogen oxide ($NO_X$) emissions in FY 2007 were 1,943 Gg, a decrease by 4.7% compared to FY 1990, and by 2.6% compared to the previous year.

Carbon monoxide (CO) emissions in FY 2007 were 2,761 Gg, a decrease by 38.1% compared to FY 1990, and a decrease by 3.4% compared to the previous year.

Non-methane volatile organic compounds (NMVOC) emissions in FY 2007 were 1,638 Gg, a decrease by 15.4% compared to FY 1990, and a decrease by 1.1% compared to the previous year.

Sulfur dioxide ($SO_2$) emissions in FY 2007were 780 Gg, a decrease by 22.9% compared to FY 1990, and a decrease by 3.0% compared to the previous year.

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# 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 from 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 $CO_2$, $CH_4$, $N_2O$, $NO_x$ (nitrogen oxide), CO (carbon monoxide), and NMVOC (non-methane volatile organic compounds) are emitted in the process.

In 2007, GHG emissions from energy sector accounted to 1,244,493 Gg-$CO_2$, and represented 90.6% of the Japan's total GHG emissions. The emissions from energy sector had increased by 15.3% compare to 1990.

## 3.2. Fuel Combustion (1.A.)

This category covers GHG emissions from the 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 the 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 the other sector.

In 2007, emissions from fuel combustion were 1,244,039 Gg-$CO_2$, and represented 90.5% of GHG of the Japan's total GHG emissions. The emissions had increased by 15.6% compared to 1990.

### 3.2.1. Energy Industries (1.A.1.)

#### *a） Source/Sink Category Description*

This source category provides methods 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).

#### *b） Methodological Issues*

The estimation methods, activity data, emission factors, and other parameters used in the Energy

[1] These emissions from waste incineration had been reported in the waste sector in previous submissions, regardless of use as energy or energy recovery. However, to comply with ERT observations and the requirements of IPCC Guidelines, the emissions are reported in the energy sector. The details are documented and described in Chapter 10.

Industry (1.A.1), Manufacturing Industry and Construction (1.A.2) and Other Sectors (1.A.4) are basically common. Therefore, the estimation method and data used for all of them is summarized in this section.

The estimation method for waste incineration with energy use and energy recovery is described in Chapter.8.

**【$CO_2$】**

●***Estimation Method***

Tier 1 Sectoral Approach has been used in accordance with the decision tree of the *Good Practice Guidance (2000)* (Page 2.10, Fig. 2.1) to calculate emissions. Country-specific emission factors are used for all types of fuel.

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

| | |
|---|---|
| E | : $CO_2$ emissions from fossil fuel combustion [ $tCO_2$ ] |
| A | : Energy consumption [ t, kl, $m^3$ ] |
| N | : Non-energy product use of fossil fuels [ t, kl, $m^3$ ] |
| GCV | : Gross calorific value [ MJ/kg, MJ/l, $MJ/m^3$ ] |
| EF | : Carbon content of the fuel [ tC/TJ ] |
| OF | : Oxidation factor |
| i | : Type of energy |
| j | : Sector |

●***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. Most of them are country-specific values.

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.

(a) Energy sources other than Blast Furnace Gas (BFG) and Town gas: Emission factors are based on the carbon content of each fuel type.

(b) BFG: During iron and steel production process, in the blast furnace and L.D. converter, the amount of energy and carbon contained in coke and PCI coal which are injected to the processes and these contained in BFG and LDG which are calculated should be theoretically balanced. Since the composition of BFG is unstable, emission factors for BFG was established with annually calculated value in order to keep carbon balance in blast furnace and L.D. converter during the iron and steel production process.

(c) Town gas: Town gas is produced from the mixture of raw materials and air dilution. In order to calculate town gas emission factors, total carbon contained in fossil fuel used as raw materials was divided by the total calorific value of produced town gas.

Table3-1 provides the emission factors for $CO_2$ by fuel types.

Table 3-1 Emission factors for fuel combustion

| Fuel | | Code | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|
| Coal | Steel Making Coal | $110 | tC/TJ | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 |
| | Coking Coal | $111 | tC/TJ | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 |
| | PCI Coal | $112 | tC/TJ | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 | 24.51 |
| | Imported Steam Coal | $130 | tC/TJ | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 |
| | Imported Coal : for general use | $131 | tC/TJ | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 |
| | Imported Coal : for power generation | $132 | tC/TJ | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 | 24.71 |
| | Indigenous Steam Coal | $135 | tC/TJ | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 |
| | Underground | $136 | tC/TJ | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 |
| | Open Pit | $137 | tC/TJ | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 | 24.90 |
| | Hard Coal, Anthracite & Lignite | $140 | tC/TJ | 25.46 | 25.46 | 25.46 | 25.46 | 25.46 | 25.46 |
| Coal Products | Coke | $161 | tC/TJ | 29.38 | 29.38 | 29.38 | 29.38 | 29.38 | 29.38 |
| | Coal Tar | $162 | tC/TJ | 20.90 | 20.90 | 20.90 | 20.90 | 20.90 | 20.90 |
| | Coal Briquette | $163 | tC/TJ | 29.38 | 29.38 | 29.38 | 29.38 | 29.38 | 29.38 |
| | Coke Oven Gas | $171 | tC/TJ | 10.99 | 10.99 | 10.99 | 10.99 | 10.99 | 10.99 |
| | Blast Furnace Gas | $172 | tC/TJ | 27.28 | 26.91 | 26.60 | 26.48 | 26.38 | 26.34 |
| | Converter Furnace Gas | $173 | tC/TJ | 38.44 | 38.44 | 38.44 | 38.44 | 38.44 | 38.44 |
| Oil | Crude Oil for Refinery | $210 | tC/TJ | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 |
| | Crude Oil for Power Generation | $220 | tC/TJ | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 |
| | Bituminous Mixture Fuel | $221 | tC/TJ | 19.96 | 19.96 | 19.96 | 19.96 | 19.96 | 19.96 |
| | Natural Gas Liquid & Condensate | $230 | tC/TJ | 18.40 | 18.40 | 18.40 | 18.40 | 18.40 | 18.40 |
| Oil Products | Slack Gasoline | $271 | tC/TJ | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 |
| | Slack Kerosene | $272 | tC/TJ | 18.51 | 18.51 | 18.51 | 18.51 | 18.51 | 18.51 |
| | Slack Diesel Oil or Gas Oil | $273 | tC/TJ | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 |
| | Slack Fuel Oil | $274 | tC/TJ | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 |
| | Cracked Gasoline | $275 | tC/TJ | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 |
| | Cracked Diesel Oil or Gas Oil | $276 | tC/TJ | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 |
| | Feedstock Oil for Refinery and Mixing | $277 | tC/TJ | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 | 18.66 |
| | Naphtha | $281 | tC/TJ | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 | 18.17 |
| | Reformed Material Oil | $282 | tC/TJ | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 |
| | Gasoline | $310 | tC/TJ | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 |
| | Premium Gasoline | $311 | tC/TJ | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 |
| | Regular Gasoline | $312 | tC/TJ | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 | 18.29 |
| | Jet Fuel | $320 | tC/TJ | 18.31 | 18.31 | 18.31 | 18.31 | 18.31 | 18.31 |
| | Kerosene | $330 | tC/TJ | 18.51 | 18.51 | 18.51 | 18.51 | 18.51 | 18.51 |
| | Gas Oil or Diesel Oil | $340 | tC/TJ | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 | 18.73 |
| | Fuel Oil A | $351 | tC/TJ | 18.90 | 18.90 | 18.90 | 18.90 | 18.90 | 18.90 |
| | Fuel Oil C | $355 | tC/TJ | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 |
| | Heating Oil B | $356 | tC/TJ | 19.22 | 19.22 | 19.22 | 19.22 | 19.22 | 19.22 |
| | Heating Oil C | $357 | tC/TJ | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 |
| | Heating Oil C for Power Generation | $358 | tC/TJ | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 | 19.54 |
| | Lublicating Oil | $365 | tC/TJ | 19.22 | 19.22 | 19.22 | 19.22 | 19.22 | 19.22 |
| | Asphalt | $371 | tC/TJ | 20.77 | 20.77 | 20.77 | 20.77 | 20.77 | 20.77 |
| | Non Asphalt Heavy Oil Products | $372 | tC/TJ | 20.77 | 20.77 | 20.77 | 20.77 | 20.77 | 20.77 |
| | Oil Coke | $375 | tC/TJ | 25.35 | 25.35 | 25.35 | 25.35 | 25.35 | 25.35 |
| | Galvanic Furnace Gas | $376 | tC/TJ | 38.44 | 38.44 | 38.44 | 38.44 | 38.44 | 38.44 |
| | Refinary Gas | $380 | tC/TJ | 14.15 | 14.15 | 14.15 | 14.15 | 14.15 | 14.15 |
| | Liquified Petroleum Gas | $390 | tC/TJ | 16.32 | 16.32 | 16.32 | 16.32 | 16.32 | 16.32 |
| Natural Gas | Liquefied Natural Gas | $410 | tC/TJ | 13.47 | 13.47 | 13.47 | 13.47 | 13.47 | 13.47 |
| | Indigenous Natural Gas | $420 | tC/TJ | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 |
| | Indigenous Natura l Gas | $421 | tC/TJ | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 |
| | Coal Mining Gas | $422 | tC/TJ | 13.47 | 13.47 | 13.47 | 13.47 | 13.47 | 13.47 |
| | Off-gas from Crude Oil | $423 | tC/TJ | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 | 13.90 |
| Town Gas | Town Gas | $450 | tC/TJ | 14.04 | 13.99 | 13.80 | 13.65 | 13.66 | 13.59 |
| | Town Gas | $460 | tC/TJ | 14.04 | 13.99 | 13.80 | 13.65 | 13.66 | 13.59 |
| | Small Scale Town Gas | $470 | tC/TJ | 16.32 | 16.32 | 16.32 | 16.32 | 16.32 | 16.32 |

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

Adequacy assessment was conducted for emission factors which were used in the inventories submitted in 2005 based on the following 3 criteria.

- Comparison with theoretical upper and lower limit
- Comparison with default values indicated in 1996 revised IPCC guidelines
- Carbon balance assessment for energy group with Energy Balance Table (*General Energy Statistics*).

Emissions factors assessed as adequate continue to be used in this inventory, and the ones assessed as inadequate were substituted by the values given in Ministry of the Environment, committee for the Greenhouse gases Emissions Estimation Methods, in its *GHGs Estimation Methods Committee Report Part 1*, August 2002.

*(b) BEG and (c) Town gas*

Values for these fuels are established with annually calculated values based on the carbon balance of their production processes. For more details, refer to Annex 2 of this report.

➢ ***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 groups, manufacturing corporations and experts.

*Gaseous Fuels*

Every result of measurement of soot concentration of boiler to generate powers in 2004 for gaseous fuels combustion shows that no soot was emitted; therefore, it is considered that gaseous fuels are completely combusted. The results of questionnaires also show that gaseous fuels are completely combusted. Hence, oxidation factor for gaseous fuels combustion was set to 1.0.

Table 3-2 Data of gaseous fuel combustion

| Fired condition | Provider | Survey |
|---|---|---|
| Complete combustion | The Federation for Electric Power Companies Japan (FEPC) | measurement of soot concentration of boiler to generate powers in 2004 |

*Liquid Fuels (Petroleum Fuels)*

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

*Solid Fuels*

Oxidation factor for solid fuels varies depending on fired condition, type of furnace, and coal property; therefore, it is quite difficult to obtain representational data set of actual measurement 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 carbon dioxide and emitted into the atmosphere during calcinations processes.
Average oxidation factor from 1990 to 2003 considering unburned carbon oxidized in firing process of coal ash eventually is 0.996, expressed as 3 significant digits. 2 significant digits are considered to be adequate in the view of other coefficients' accuracy; therefore, oxidation factor for solid fuels is set to 1.0 rounding off to two significant digits.

●***Activity Data***

The data given in the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy were used for the activity data. *General Energy Statistics* macroscopically determines the forms into which the coal, oil, and other energy sources imported into or produced in Japan are converted. It also identifies the sector in which the energy sources were consumed, and in what forms, to give an overview of Japan's energy supply and demand. *General Energy Statistics* provides a comprehensive overview of domestic energy supply and demand, with energy sources and sectors arranged in a matrix.

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] which reports energy consumption associated with electric power generation by electric power suppliers, and "Power Generation, Independent Power Producing" [#2150]; "District Heat Supply" [#2350] which provides 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] (Numbers in parentheses indicate corresponding sector numbers in the *General Energy Statistics*).

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

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

| CRF | | | Japan's Energy Balance Table | |
|---|---|---|---|---|
| 1A1 | | Energy Industries | | |
| | 1A1a | Public Electricity and Heat Production | Power Genertion, General Electric Utilities | #2110 |
| | | | Own use, General Electric Utilities | #2911 |
| | | | Power Genertion, Independent Power Producing | #2150 |
| | | | Own use, Independent Power Producing | #2912 |
| | | | District Heat Supply | #2350 |
| | | | Own use, District Heat Supply | #2913 |
| | 1A1b | Petroleum Refining | Own use, Oil Refinary | #2916 |
| | 1A1c | Manufacture of Solid Fuels and Other Energy Industries | Own use, Town Gas | #2914 |
| | | | Own use, Steel Coke | #2915 |
| | | | Own use, Other Conversion | #2917 |

➢ ***Gross calorific value***

Gross calorific values used in Japan's Energy Balance Table (*General Energy Statistics*) are adopted. Table 3-4 shows trends in gross calorific value for each fuel type. Japan's Energy Balance Table (*General Energy Statistics*) is adopting actual calorific values based on calculation 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 document are adopted. The standard calorific value is revised once every 5 years.

Table 3-4 Trends in gross calorific value of each fuel type

| Fuel | | Code | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|
| Coal | Steel Making Coal | $110 | MJ/kg | 31.81 | 30.53 | 29.10 | 29.10 | 29.10 | 29.10 |
| | Coking Coal | $111 | MJ/kg | 31.81 | 30.53 | 29.10 | 29.10 | 29.10 | 29.10 |
| | PCI Coal | $112 | MJ/kg | 31.81 | 30.53 | 28.20 | 28.20 | 28.20 | 28.20 |
| | Imported Steam Coal | $130 | MJ/kg | 25.95 | 25.95 | 26.60 | 25.70 | 25.70 | 25.70 |
| | Imported Coal : for general use | $131 | MJ/kg | 25.95 | 25.95 | 26.60 | 25.70 | 25.70 | 25.70 |
| | Imported Coal : for power generation | $132 | MJ/kg | 24.92 | 26.13 | 26.39 | 25.49 | 25.62 | 25.52 |
| | Indigenous Steam Coal | $135 | MJ/kg | 24.28 | 24.28 | 22.50 | 22.50 | 22.50 | 22.50 |
| | Underground | $136 | MJ/kg | 24.28 | 24.28 | 23.20 | 23.20 | 23.20 | 23.20 |
| | Open Pit | $137 | MJ/kg | 18.70 | 18.70 | 18.70 | 18.70 | 18.70 | 18.70 |
| | Hard Coal, Anthracite & Lignite | $140 | MJ/kg | 27.21 | 27.21 | 27.20 | 26.90 | 26.90 | 26.90 |
| Coal Products | Coke | $161 | MJ/kg | 30.14 | 30.14 | 30.10 | 29.40 | 29.40 | 29.40 |
| | Coal Tar | $162 | MJ/kg | 37.26 | 37.26 | 37.26 | 37.26 | 37.26 | 37.26 |
| | Coal Briquette | $163 | MJ/kg | 23.90 | 23.90 | 23.90 | 23.90 | 23.90 | 23.90 |
| | Coke Oven Gas | $171 | MJ/m$^3$N | 21.51 | 21.57 | 21.27 | 21.42 | 21.38 | 21.28 |
| | Blast Furnace Gas | $172 | MJ/m$^3$N | 3.51 | 3.59 | 3.64 | 3.41 | 3.41 | 3.41 |
| | Converter Furnace Gas | $173 | MJ/m$^3$N | 8.37 | 8.37 | 8.41 | 8.41 | 8.41 | 8.41 |
| Oil | Crude Oil for Refinery | $210 | MJ/l | 38.34 | 38.27 | 38.22 | 38.12 | 38.12 | 38.15 |
| | Crude Oil for Power Generation | $220 | MJ/l | 39.05 | 39.15 | 39.59 | 38.50 | 39.26 | 39.53 |
| | Bituminous Mixture Fuel | $221 | MJ/kg | 30.06 | 30.31 | 29.86 | 22.44 | 22.44 | 22.44 |
| | Natural Gas Liquid & Condensate | $230 | MJ/l | 35.74 | 35.51 | 35.41 | 35.03 | 35.01 | 35.46 |
| Oil Products | Slack Gasoline | $271 | MJ/l | 33.63 | 33.63 | 33.57 | 33.55 | 33.55 | 33.54 |
| | Slack Kerosene | $272 | MJ/l | 36.78 | 36.79 | 36.76 | 36.74 | 36.74 | 36.74 |
| | Slack Diesel Oil or Gas Oil | $273 | MJ/l | 38.56 | 38.59 | 38.58 | 38.57 | 38.56 | 38.57 |
| | Slack Fuel Oil | $274 | MJ/l | 41.82 | 41.77 | 41.79 | 41.77 | 41.78 | 41.81 |
| | Cracked Gasoline | $275 | MJ/l | 33.63 | 33.63 | 33.57 | 33.55 | 33.55 | 33.54 |
| | Cracked Diesel Oil or Gas Oil | $276 | MJ/l | 38.56 | 38.59 | 38.58 | 38.57 | 38.56 | 38.57 |
| | Feedstock Oil for Refinery and Mixing | $277 | MJ/l | 38.34 | 38.27 | 38.22 | 38.12 | 38.12 | 38.15 |
| | Naphtha | $281 | MJ/l | 33.63 | 33.63 | 33.57 | 33.55 | 33.55 | 33.54 |
| | Reformed Material Oil | $282 | MJ/l | 35.09 | 35.09 | 35.09 | 35.09 | 35.09 | 35.09 |
| | Gasoline | $310 | MJ/l | 34.57 | 34.61 | 34.60 | 34.59 | 34.58 | 34.58 |
| | Premium Gasoline | $311 | MJ/l | 35.09 | 35.09 | 35.09 | 35.09 | 35.09 | 35.09 |
| | Regular Gasoline | $312 | MJ/l | 34.48 | 34.48 | 34.48 | 34.48 | 34.48 | 34.48 |
| | Jet Fuel | $320 | MJ/l | 36.42 | 36.42 | 36.70 | 36.70 | 36.70 | 36.70 |
| | Kerosene | $330 | MJ/l | 36.78 | 36.79 | 36.76 | 36.74 | 36.74 | 36.74 |
| | Gas Oil or Diesel Oil | $340 | MJ/l | 38.11 | 38.09 | 38.18 | 37.76 | 37.86 | 37.96 |
| | Fuel Oil A | $351 | MJ/l | 39.74 | 39.61 | 39.33 | 39.08 | 39.97 | 40.05 |
| | Fuel Oil C | $355 | MJ/l | 42.68 | 42.18 | 41.97 | 42.00 | 41.96 | 42.16 |
| | Heating Oil B | $356 | MJ/l | 40.19 | 40.19 | 40.40 | 40.40 | 40.40 | 40.40 |
| | Heating Oil C | $357 | MJ/l | 42.68 | 42.18 | 41.97 | 42.00 | 41.96 | 42.16 |
| | Heating Oil C for Power Generation | $358 | MJ/l | 41.06 | 41.12 | 41.33 | 41.19 | 41.24 | 41.21 |
| | Lublicating Oil | $365 | MJ/l | 40.19 | 40.19 | 40.20 | 40.20 | 40.20 | 40.20 |
| | Asphalt | $371 | MJ/kg | 41.64 | 41.15 | 40.95 | 40.97 | 40.94 | 41.13 |
| | Non Asphalt Heavy Oil Products | $372 | MJ/kg | 41.64 | 41.15 | 40.95 | 40.97 | 40.94 | 41.13 |
| | Oil Coke | $375 | MJ/kg | 35.58 | 35.58 | 35.60 | 29.90 | 29.90 | 29.90 |
| | Galvanic Furnace Gas | $376 | MJ/m$^3$N | 8.37 | 8.37 | 8.41 | 8.41 | 8.41 | 8.41 |
| | Refinary Gas | $380 | MJ/m$^3$N | 39.35 | 39.35 | 44.90 | 44.90 | 44.90 | 44.90 |
| | Liquified Petroleum Gas | $390 | MJ/kg | 50.23 | 50.23 | 50.20 | 50.80 | 50.80 | 50.80 |
| Natural Gas | Liquefied Natural Gas | $410 | MJ/kg | 54.60 | 54.57 | 54.55 | 54.57 | 54.53 | 54.55 |
| | Indigenous Natural Gas | $420 | MJ/m$^3$N | 42.09 | 42.39 | 42.55 | 42.87 | 43.57 | 44.61 |
| | Indigenous Natura l Gas | $421 | MJ/m$^3$N | 42.09 | 42.39 | 42.55 | 42.87 | 43.57 | 44.61 |
| | Coal Mining Gas | $422 | MJ/m$^3$N | 36.00 | 36.00 | 16.70 | 16.70 | 16.70 | 16.70 |
| | Off-gas from Crude Oil | $423 | MJ/m$^3$N | 42.09 | 42.39 | 42.55 | 42.87 | 43.57 | 44.61 |
| Town Gas | Town Gas | $450 | MJ/m$^3$N | 41.86 | 41.86 | 41.10 | 44.80 | 44.80 | 44.80 |
| | Town Gas | $460 | MJ/m$^3$N | 41.86 | 41.86 | 41.10 | 44.80 | 44.80 | 44.80 |
| | Small Scale Town Gas | $470 | MJ/m$^3$N | 100.50 | 100.50 | 100.50 | 100.50 | 100.50 | 100.50 |

**【$CH_4$, $N_2O$】**

●***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 for Japan, Tier 2 country-specific emission factors were used to calculate emissions in accordance with the *1996 Revised IPCC Guidelines* and *Good Practice Guidance* (2000). However, in residential and other sectors in which activity data for different furnace types cannot be used, Tier 1 IPCC default emission factors were used.

Emissions were calculated by multiplying fuel-specific, furnace-specific and sector-specific activity data by fuel-specific and furnace-specific emission factors.

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

| | |
|---|---|
| E | : Emissions from combustion of fuel by stationary sources ($kgCH_4$, $kgN_2O$) |
| $EF_{ij}$ | : Emission factor for fuel type i, furnace type j ($kgCH_4/TJ$, $kgN_2O/TJ$) |
| $A_{ijk}$ | : Fuel consumption for fuel type i, furnace type j, sector k (TJ) |
| i | : Fuel type |
| j | : Furnace type |
| k | : Sector |

●***Emission Factors***

Based on data obtained from surveys conducted in Japan (Table 3-6), chimney flue $CH_4$, $N_2O$ and $O_2$ concentrations, and the theoretical (dry) exhaust gas volumes, theoretical air volumes, and higher heating values shown in Table 3-5 were employed to establish emission factors for each kind of facility using the combustion calculation formula. For $CH_4$ and $N_2O$ emissions from electric arc furnaces, combustion calculation was carried out using measurement results for $CH_4$ and $N_2O$ concentrations in exhaust gas, dry exhaust gas volume per unit time, and calorific value per unit time.

Emission factors for each kind of facility were averaged after dividing facilities according to fuel and furnace types, and $CH_4$ and $N_2O$ emission factors were established (Table 3-7, Table 3-8). Anomalous values were excluded according to t-testing or expert opinion when calculating average values.

Table 3-5 Theoretical exhaust gas and air volumes, higher heating value for different fuels

| Fuel type | Fixed unit | Theoretical exhaust gas volume (dry) | Higher heating value | Theoretical air volume | Remarks |
|---|---|---|---|---|---|
| | | $m^3_N$/l,kg,$m^3$N | kJ/l,kg,$m^3$N,kWh | $m^3_N$/l,kg,$m^3$N | |
| Heavy oil A | l | 8.900 | 39,100 | 9.500 | 1 |
| Heavy oil B | l | 9.300 | 40,400 | 9.900 | 1 |
| Heavy 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 |
| Linz-Donawitz (LD) gas | $m^3$ | 2.200 | 8,410 | 1.500 | 1 |
| Refinery gas (offgas) | $m^3$ | 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 *Research of Air Pollutant Emissions from Stationary Sources* (hereafter MAP Survey), 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, standard calorific values given in General Energy Statistics were used for items marked 1, and standard values given in the MAP Survey (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 etc.

Table 3-6 References for measurement data used in 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 Kitakyusyu, *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 Sociality 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 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 |

Table 3-7 $CH_4$ emission factors for different fuels and furnaces (unit: kg-$CH_4$/TJ)

| Furnace type | Fuel type | Emission factor | Remarks |
|---|---|---|---|
| Boiler | Heavy oils B and C, crude oil | 0.10 | Average of 9 facilities |
| Boiler | Heavy oil A, diesel oil, kerosene, naphtha, other liquid fuels | 0.25 | Average of 2 facilities |
| Boiler | Gaseous fuel | 0.22 | Average of 5 facilities |
| Boiler | Steam coal, coke, other solid fuels | 0.13 | Average of 7 facilities |
| Boiler | Harvested wood, charcoal | 72 | Average of 4 facilities |
| Boiler | Pulping waste liquor | 4.3 | Average of 2 facilities |
| Sintering furnace for smelting of metals (except copper, lead, zinc) | Solid fuel, liquid fuel, gaseous fuel | 30 | Average of 6 facilities |
| Palletizing furnace (steel and non-ferrous metal) | Solid fuel, liquid fuel, gaseous fuel | 1.6 | Average of 2 facilities |
| Metal rolling furnace, metal treating furnace, metal forging furnace | Liquid fuel, gaseous fuel | 0.42 | Average of 11 facilities |
| Petroleum and gas furnaces | Liquid fuel, gaseous fuel | 0.15 | Average of 27 facilities |
| Catalytic regenerator | Coke, carbon | 0.054 | Average of 11 facilities |
| Brick kiln, ceramic kiln, and other kiln | Solid fuel, liquid fuel, gaseous fuel | 1.5 | Average of 2 facilities |
| Aggregate drying kiln, cement raw material drying kiln, brick raw material drying kiln | Solid fuel, liquid fuel, gaseous fuel | 27 | Average of 6 facilities |
| Other drying kilns | Solid fuel, liquid fuel, gaseous fuel | 6.1 | Average of 8 facilities |
| Electric arc furnace | Electricity | 13 | Average of 6 facilities |
| Other industrial furnaces | Solid fuel | 13 | Average of 14 facilities |
| Other industrial furnaces | Liquid fuel | 0.79 | Average of 14 facilities |
| Other industrial furnaces | Gaseous fuel | 2.1 | Average of 6 facilities |
| Gas turbine | Liquid fuel, gaseous fuel | 0.75 | Average of 11 facilities |
| Diesel engine | Liquid fuel, gaseous fuel | 0.67 | Average of 8 facilities |
| Gas engine, petrol engine | Liquid fuel, gaseous fuel | 54 | Average of 6 facilities |
| Household equipment | Solid fuel | 290 | IPCC default value converted to higher heating value |
| Household equipment | Liquid fuel | 9.5 | IPCC default value converted to higher heating value |
| Household equipment | Gaseous fuel | 4.5 | IPCC default value converted to higher heating value |
| Household equipment | Biomass fuel | 290 | IPCC default value converted to higher heating value |

Table 3-8 $N_2O$ emission factors for different fuels and furnaces (unit: kg-$N_2O$/TJ)

| Furnace type | Fuel type | Emission factor | Remarks |
|---|---|---|---|
| Boiler | Heavy oils B and C, crude oil | 0.21 | Average of 10 facilities |
| Boiler | Heavy oil A, diesel oil, kerosene, naphtha, other liquid fuels | 0.18 | Average of 2 facilities |
| Boiler | Gaseous fuel | 0.16 | Average of 5 facilities |
| Boiler (other than fluidized bed boilers) | Solid fuel | 0.83 | Average of 9 facilities |
| Normal pressure fluidized bed boiler | Solid fuel | 53 | Average of 11 facilities |
| Pressurized fluidized bed boiler | Steam coal | 5.2 | Data from 1 facility |
| Boiler | Pulping waste liquor | 0.17 | Average of 2 facilities |
| Blast furnace | Coke oven gas, blast furnace gas, other gaseous fuel | 0.050 | Average of 2 facilities |
| Petroleum furnace, gas furnace | Liquid fuel, gaseous fuel | 0.20 | Average of 27 facilities |
| Catalytic regenerator | Coke, carbon | 7.3 | Average of 12 facilities |
| Electric arc furnace | Electricity | 3.3 | Average of 6 facilities |
| Coke oven | Town gas, coke oven gas, blast furnace gas, converter gas, offgas, other gaseous fuels | 0.15 | Average of 3 facilities |
| Other industrial furnace | Solid fuel | 1.1 | Average of 20 facilities |
| Other industrial furnace | Liquid fuel | 1.7 | Average of 31 facilities |
| Other industrial furnace | Gaseous fuel | 1.1 | Average of 18 facilities |
| Gas turbine | Liquid fuel, gaseous fuel | 0.54 | Average of 12 facilities |
| Diesel engine | Liquid fuel, gaseous fuel | 2.1 | Average of 9 facilities |
| Gas engine, petrol engine | Liquid fuel, gaseous fuel | 0.83 | Average of 7 facilities |
| Household equipment | Solid fuel | 1.3 | IPCC default value converted to higher heating value |
| Household equipment | Liquid fuel | 0.57 | IPCC default value converted to higher heating value |
| Household equipment | Gaseous fuel | 0.090 | IPCC default value converted to higher heating value |
| Household equipment | Biomass fuel | 3.8 | IPCC default value converted to higher heating value |

●***Activity Data***

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 different furnace types proportionally to fuel consumption data in the MAP survey to obtain the activity data for each sector, each fuel type and each furnace type.

Because stationary combustion fuel consumption data for the different types of furnace is not available in the General Energy Statistics, data from the MAP Survey, which provides details on fuel consumption for different types of furnace and fuel, was used to estimate fuel consumption for different furnace types.

***Outline of the MAP Survey***

The MAP Survey is a statistical survey conducted to (1) promote 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 that are registered to a local government and in facilities that emit 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 with survey questionnaires. The response sheets and this survey's explanations are distributed to target facilities mentioned above. Complete enumeration surveys, in the form of the *MAP Survey*, were carried out in fiscal 1992, 1995, 1996, and 1999, in relation to all facilities emitting soot and smoke.

The procedure for calculating activity data is as follows:

1) Fuel consumption data from the MAP Survey 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.

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

| | |
|---|---|
| $A_{ijk}$ | : 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 |

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

| | |
|---|---|
| $A_{MAPijk}$ | : Fuel consumption for fuel type i, furnace type j, sector k according to MAP Survey (TJ) |

4) MAP Survey fuel-specific, furnace-specific, and sector-specific fuel consumption is used as activity data for the consumption of fuels (such as charcoal) not included in the General Energy Statistics, and furnaces for which General Energy Statistics fuel consumption data cannot be used (in specific terms, electricity consumption of electric arc furnaces and carbon fuels of catalytic regenerators).

5) In the residential sector, fuel consumption for different fuel types provided in the General Energy Statistics is used as activity data.

For years in which exhaustive MAP surveys were not carried out, the percentages of fuel consumption accounted for by each furnace type were interpolated using the data obtained in the years exhaustive survey carried out.

The $N_2O$ emissions from solid fuel in 1.A.1.a (Public Electricity and Heat Production) increased between 1994 and 1995. The reason for the increase is that a new large sized fluidized-bed boiler for power generation went on line in 1995. As a result, the solid fuel consumption of fluidized-bed boiler for public power generation increased in 1995, resulting in an increase of $N_2O$ emissions from solid fuel in this category.

### *c） Uncertainties and Time-series Consistency*

**●*Uncertainties***

**【$CO_2$】**

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 of emission factors 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. As a result, the uncertainty for emissions was determined to be 1% for $CO_2$ emissions from fuel combustion. A summary of uncertainty assessment methods is provided in Annex 7.

**【$CH_4$, $N_2O$】**

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 standard deviation and the percentage of data collection indicated in MAP Survey. 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 are provided in Annex 7.

**●*Time-series Consistency***

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

The same carbon emission factors have been used from FY 1990 to the current year as discussed in the Emission Factors section, with the exception of blast furnace gas and town gas. These emission factors have been calculated by a consistent estimation method in all time series.

The emission factors for $CH_4$ and $N_2O$ have been calculated by a consistent estimation method since FY 1990.

The activity data was used from data in *General Energy Statistics* in all time series, and the statistics are 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 *Good Practice Guidance (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. Details of the QA/QC activities are provided in Annex 6.

### *e） Source-specific Recalculations*

$CO_2$, $CH_4$, and $N_2O$ emissions in FY 2006 were recalculated because of the revision of the values in FY 2006 reported in the *General Energy Statistics* which were used as the basis for activity data in the category of *1.A. Fuel Combustion Activities*.

Emissions from waste used for energy and from the incineration of wastes with energy recovery, which had been reported in the waste sector in previous submissions, are reported in the 'Other fuels' of the energy sector in the 2009 inventory submission to comply with ERT observations and the requirements of IPCC documents. Recalculations were performed for all years.

### *f） Source-specific Planned Improvements*

・ The use of fuel consumption data in the MAP Survey for FY 2002 onward is prohibited for any purposes other than the original one specified for the Map Survey, while that is not the case with the data in the MAP Survey for FY 1999 and earlier years. Therefore, for emission estimation after FY 2000, the ratio of each furnace type associated with consumption of each fuel type in each sector estimated based on the data in FY 1999 was used. It is currently under consideration by the government whether an arrangement should be made to enable use of the data in the MAP Survey for FY 2002 onward.

### 3.2.2. Manufacturing Industries and Construction (1.A.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).

#### *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 *General Energy Statistics* were used for activity data, as was the case for the Energy Industry (1.A.1).

Activity data for manufacturing industry sectors were calculated by totaling energy consumption from production activities in factories and offices (final energy consumption), energy consumption related to non-utility power generation for use in one’s own factories and offices (non-utility power generation), and energy consumption related to steam production for use in own factories and offices (industrial steam) shown in *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), 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) decreases between 1997 and 1998, and increases between 1998 and 1999 because of revisions made to 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.* 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 has been changed. For these reasons, and the IEF of $CO_2$ emissions from liquid fuels in 1.A.2.f (Other) changed. The details are documented and described in Annex.2.

Table 3-9 shows correspondence between sectors of Japan's Energy Balance Table and of the CRF (1.A.2).

Table 3-9 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 & SMEs | Auto: Others | #2250 |
| | | | Final Energy Consumption, Other Industries & SMEs | #6900 |
| | | | Non-Energy, Other Industries & SMEs | #9720 |

***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 *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. Details of the QA/QC activities are provided in Annex 6.

***e) Source-specific Recalculations***

$CO_2$, $CH_4$, and $N_2O$ emissions in FY 2006 were recalculated because the values in FY 2006 reported in the *General Energy Statistics* which are used as activity data were revised and the emissions from wastes used for energy and from the incineration of wastes with energy recovery, which had been reported in the waste sector in previous submissions, are reported in the 'Other fuel' of the energy sector.
In addition, the emissions from Mining, which had been reported in the "Other (1.A.5)" in the previous submissions, are reported in the "Manufacturing Industries and Construction (1.A.2)".

***f) Source-specific Planned Improvements***

See Section 3.2.1 f)

### 3.2.3. 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).

***b) Methodological Issues***

●***Estimation Method***

See Section 3.2.1 b).
Because $CO_2$ emissions from natural gas-powered vehicles and steam locomotives include Commercial /Institutional section in Other Sectors (1.A.4), $CO_2$ emissions from these source are reported as "IE."

●***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 sulphur content imported from Middle East must be decomposed and go through ultradeep desulfurization to be low-sulphur diesel oil (<10ppm) according to Japanese automobile exhaust gas regulations. The other reasons is because gas oil used for purposes other than road transport is called "Heavy oil A" to distinguish it from diesel oil. The carbon balance of Japanese petroleum refineries including diesel oil and heavy oil A nearly matches according to statistics, so these carbon emission factors are not irregular.

●***Activity Data***

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

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 the purposes other than combustion and was considered not emitting $CO_2$, these values were deducted.

Table 3-10 Correspondence between sectors of Japan's Energy Balance Table and 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 | #9850 |
| | 1A3e | Other Transportation | - | - |

### 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 *Good Practice Guidance (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. Details of the QA/QC activities are provided in Annex 6.

### e) *Source-specific Recalculations*

See Section 3.2.1 e).

Because $CO_2$ emissions from natural gas-powered vehicles and steam locomotives include Commercial /Institutional section (1.A.4.a) in Other Sectors (1.A.4), $CO_2$ emissions from these sources are reported as "IE."

### f) *Source-specific Planned Improvements*

There are no major planned improvements in this source category.

## 3.2.4. Mobile Combustion (1.A.3.:$CH_4$ , $N_2O$)

This section provides the estimation methods for $CH_4$ and $N_2O$ emissions from Mobile Combustion from Civil Aviation (1.A.3.a), Road Transportation (1.A.3.b), Railways (1.A.3.c), and Navigation (1.A.3.d).

### 3.2.4.1. 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 methane and nitrous oxide 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 Decision Tree of the *Good Practice Guidance (2000)* (Page 2.58, Fig. 2.7).

*Methane and nitrous oxide 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 in domestic routes

*Methane and nitrous oxide emissions from domestic airliner during cruising using jet fuel*
= Emission factor associated with jet fuel consumption × Jet fuel consumption by aircraft during cruising in domestic routes

*Methane and nitrous oxide emission associated with flight of gasoline-powered domestic aircraft*
= Emission factor associated with consumption of aviation gasoline × Consumption of aviation gasoline by aircraft in domestic routes

●***Emission Factors***

➢ ***Jet fuel***

The default values given in the *Revised 1996 IPCC Guidelines* are used for emission factors for methane and nitrous oxide for LTO. The values used for emission factors for methane and nitrous oxide 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). The following table provides the emission factors for methane and nitrous oxide at LTO and cruising.

➢ ***Aviation gasoline***

The default values given in the *Revised 1996 IPCC Guidelines* are used for emission factors for methane and nitrous oxide.

Table 3-11 Methane and nitrous oxide emission factors for aircraft

| | | $CH_4$ | $N_2O$ |
|---|---|---|---|
| jet aircraft (Jet fuel) | During takeoff and landing* | 0.3 [kg-$CH_4$/LTO] | 0.1 [kg-$N_2O$/LTO] |
| | During flight | 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/takeoff cycle

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

● ***Activity Data***

➢ ***Jet fuel***

The number of takeoffs and landings given in the *Statistical Yearbook of Air Transport* of the Ministry of Land, Infrastructure, Transport and Tourism is used as activity data at takeoff and landing. Fuel Consumption for takeoff and landing was calculated by multiplying fuel consumption for one takeoff or landing given in the IPCC/OECD guidelines, by the number of takeoffs and landings given above.

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

➢ ***Aviation gasoline***

Consumption (converted into net calorific value) of gasoline in airplane sector taken from the *General Energy Statistics* of the Agency for Natural Resources and Energy was used for activity data.

Table 3-12 Activity Data associated with emissions from aircraft

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| number of LTO cycle | LTO | 430,654 | 532,279 | 667,559 | 715,767 | 742,123 | 741,430 |
| Jet fuel comsumption of Cruise | kl | 2,330,514 | 3,223,547 | 3,537,205 | 3,543,856 | 3,675,250 | 3,560,400 |
| Gasoline comsumption | kl | 5,345 | 6,029 | 4,287 | 7,662 | 8,157 | 4,184 |

### c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (2000)* (200% for $CH_4$ and 10,000% for $N_2O$) were applied. 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***

Emission factors were used same values from FY 1990 to FY 2006. Activity data for jet fuel from the *Statistical Yearbook of Air Transport* and aviation gasoline from the *General Energy Statistics* have been used consistently from FY 1990 to FY2006.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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.

### e) Source-specific Recalculations

No recalculations were performed.

### f) Source-specific Planned Improvements

No improvements are planned.

### 3.2.4.2. Road Transportation (1.A.3.b.)

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

Table 3-13 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. | ○ | — | — | — |
| Light cargo truck | Light vehicle used for transportation of cargo | ○ | — | — | — |
| Passenger vehicle | Regular passenger vehicle or small vehicle used for transportation of people, with a capacity of 10 persons or less. | ○ | ○ | ○ | — |
| Bus | Regular passenger vehicle or small vehicle used for transportation of people, with a capacity of 11 persons or more. | ○ | ○ | — | — |
| Small cargo truck | Small vehicle used for transportation of cargo. | ○ | ○ | — | — |
| Regular cargo truck | Regular vehicle used for transportation of cargo. | ○ | ○ | — | — |
| Special-purpose vehicle | Regular, small or light vehicle used for special purposes, including flushers, advertising vans, hearses, and others. | ○ | ○ | — | — |
| NPG vehicle | Any of the above vehicles that use natural gas as fuel. | — | — | — | ○ |
| Motorcycle | Two-wheeled vehicle | ○ | — | — | — |

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.

#### 3.2.4.2.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***

Emissions have been calculated distance travel per type of vehicle by emission factors using the Tier 3 method, in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.45, Fig. 2.5). The country-specific emission factors were used for some category of vehicle, and the default emission factors were used for the other category of vehicle. The activity data was estimated by using running mileage and fuel efficiency which were provided from the Ministry of Land, Infrastructure, Transport and Tourism's *Statistical Yearbook of Motor Vehicle Transport*..

●***Emission Factors***

Emission factors for methane and nitrous oxide have been established for each type of fuel in each category of vehicle, using the data shown in table 3-14. "JAMA data": the emission factors were calculated using driving mode test data provided by Japan Automobile Manufacturers Association, Inc.(JAMA)[2]. "Measured data" were using actual Japanese data. The method used to establish emission factors was to take a weighted average of the emission factors estimated for each class of running speed, using the proportion of mileage by 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 motor vehicle operation in Japan because the proportion of mileage by each class of running speed during congestion was applied. "1996GL" and "GPG(2000)" mean the emission factors were established using the default values in IPCC guidelines.

Detailed method for the determination of the emission factors are described in the *Greenhouse Gases Estimation Methods Committee Report – Transportation* (Ministry of Environment; February, 2006).

Table 3-14 Data source of the emission factors of vehicle

| Vehicle Type | Gasoline engine | | Diesel engin | |
|---|---|---|---|---|
| | $CH_4$ | $N_2O$ | $CH_4$ | $N_2O$ |
| 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 | Measured data | JAMA data |
| Regular cargo truck | 1996GL | GPG(2000) | JAMA data | JAMA data |
| Special-purpose vehicle | 1996GL | GPG(2000) | Measured data | 1996GL |

Table 3-15 Methane emission factors for road transportation

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Light Vehicle | $gCH_4$/km | 0.008 | 0.008 | 0.008 | 0.007 | 0.007 | 0.007 |
| | Passenger Vehicle (including LPG) | $gCH_4$/km | 0.015 | 0.015 | 0.014 | 0.011 | 0.010 | 0.010 |
| | Light Cargo Truck | $gCH_4$/km | 0.020 | 0.020 | 0.019 | 0.013 | 0.011 | 0.010 |
| | Small Cargo Truck | $gCH_4$/km | 0.022 | 0.021 | 0.021 | 0.015 | 0.013 | 0.012 |
| | Regular Cargo Truck | $gCH_4$/km | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 |
| | Bus | $gCH_4$/km | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 |
| | Special Vehicle | $gCH_4$/km | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 | 0.035 |
| Diesel | Passenger Vehicle | $gCH_4$/km | 0.011 | 0.012 | 0.012 | 0.013 | 0.013 | 0.013 |
| | Small Cargo Truck | $gCH_4$/km | 0.0088 | 0.0091 | 0.0079 | 0.0076 | 0.0076 | 0.0076 |
| | Regular Cargo Truck | $gCH_4$/km | 0.017 | 0.016 | 0.015 | 0.015 | 0.015 | 0.015 |
| | Bus | $gCH_4$/km | 0.019 | 0.018 | 0.017 | 0.017 | 0.017 | 0.017 |
| | Special Vehicle | $gCH_4$/km | 0.017 | 0.015 | 0.013 | 0.013 | 0.013 | 0.013 |

[2] JAMA data were provided by test mode. The emission factors were calculated using "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.

Table 3-16 Nitrous oxide emission factors for road transportation

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Light Vehicle | $gN_2O/km$ | 0.015 | 0.015 | 0.014 | 0.010 | 0.009 | 0.009 |
| | Passenger Vehicle (including LPG) | $gN_2O/km$ | 0.024 | 0.024 | 0.020 | 0.012 | 0.011 | 0.010 |
| | Light Cargo Truck | $gN_2O/km$ | 0.024 | 0.024 | 0.022 | 0.013 | 0.011 | 0.010 |
| | Small Cargo Truck | $gN_2O/km$ | 0.020 | 0.021 | 0.021 | 0.013 | 0.011 | 0.010 |
| | Regular Cargo Truck | $gN_2O/km$ | 0.039 | 0.041 | 0.039 | 0.038 | 0.035 | 0.035 |
| | Bus | $gN_2O/km$ | 0.045 | 0.046 | 0.044 | 0.041 | 0.043 | 0.043 |
| | Special Vehicle | $gN_2O/km$ | 0.039 | 0.042 | 0.037 | 0.030 | 0.030 | 0.030 |
| Diesel | Passenger Vehicle | $gN_2O/km$ | 0.006 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 |
| | Small Cargo Truck | $gN_2O/km$ | 0.009 | 0.010 | 0.010 | 0.008 | 0.008 | 0.008 |
| | Regular Cargo Truck | $gN_2O/km$ | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 | 0.015 |
| | Bus | $gN_2O/km$ | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |
| | Special Vehicle | $gN_2O/km$ | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 | 0.025 |

● ***Activity Data***

Estimates of annual running mileage by each category of vehicle and by each type of fuel have been used as activity data. The method of estimating activity data was to multiply the proportion of running mileage for each fuel, which was calculated from fuel consumption and fuel efficiency, by the running distance for each category of vehicle given in the Ministry of Land, Infrastructure, Transport and Tourism's *Statistical Yearbook of Motor Vehicle Transport*.

Table 3-17 Distance traveled per type of vehicle

| vehicle type | fuel type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Light vehicle | Gasolin | $10^6$ vehicles km | 15,281 | 39,386 | 70,055 | 102,601 | 108,721 | 116,442 |
| Passenger vehicle | Gasolin | $10^6$ vehicles km | 289,697 | 323,022 | 363,991 | 372,663 | 366,782 | 363,707 |
| | Diesel Oil | $10^6$ vehicles km | 42,252 | 66,787 | 58,832 | 30,902 | 24,799 | 21,445 |
| | LPG | $10^6$ vehicles km | 18,368 | 17,192 | 15,382 | 13,971 | 13,807 | 13,427 |
| Bus | Gasolin | $10^6$ vehicles km | 95 | 32 | 21 | 46 | 54 | 69 |
| | Diesel Oil | $10^6$ vehicles km | 7,016 | 6,736 | 6,598 | 6,605 | 6,601 | 6,658 |
| Light cargo truck | Gasolin | $10^6$ vehicles km | 85,336 | 84,534 | 74,914 | 73,789 | 73,409 | 73,382 |
| Small cargo truck + Cargo passenger truck | Gasolin | $10^6$ vehicles km | 36,981 | 25,892 | 24,988 | 26,597 | 27,096 | 27,051 |
| | Diesel Oil | $10^6$ vehicles km | 55,428 | 62,032 | 57,221 | 41,674 | 39,100 | 38,064 |
| Regular cargo truck | Gasolin | $10^6$ vehicles km | 447 | 361 | 331 | 741 | 880 | 993 |
| | Diesel Oil | $10^6$ vehicles km | 66,434 | 78,086 | 82,693 | 78,866 | 79,873 | 80,516 |
| Special vehicle | Gasolin | $10^6$ vehicles km | 827 | 851 | 1,584 | 1,556 | 1,603 | 1,690 |
| | Diesel Oil | $10^6$ vehicles km | 10,420 | 15,373 | 19,115 | 18,869 | 19,887 | 20,185 |

● ***$N_2O$ emissions from gasoline vehicle in Japan***

"Japan 1978 Emission Regulation" was stipulated in 1978, and 3 way catalyst have stated to install to gasoline automobiles in Japan. Then, $N_2O$ emissions per mileage (km) were increased. Until around 1986 when automobile installed 3 way catalyst became widely used, $N_2O$ emissions per mileage (km) kept to increase. Until 1997, new emission regulation on automobile has not stipulated, then, $N_2O$ emissions per mileage (km) were stable from 1986 to 1997.From 1997, Low Emission Vehicle were started to sell. From 2000, "Japan 2000 Emission Regulation" was stipulated, and $N_2O$ emissions per mileage (km) were stated to decrease with installation of Close coupled Catalytic Converter. After 1997, trend of $N_2O$ emissions per mileage (km) was decreasing.

● ***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 methane and nitrous oxide associated with the use of vehicles using biomass as fuel has been reported as "NO".

➢ ***Other (Methanol)***

The number of methanol vehicles owned in Japan was only 19 at the end of March 2007 (data surveyed by the Ministry of Land, Infrastructure, Transport and Tourism). 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, default values given in the *Good Practice Guidance (2000)* (40% for $CH_4$ and 50% for $N_2O$) were applied. For the uncertainty for activity data, 50% for standard values determined by the Committee for the Greenhouse Gas Emission Estimation Methods was applied. As a result, the uncertainties of the emission from all road transportation including natural gas-powered vehicles and motorcycles 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***

Emission factors were used same values from FY 1990 to FY 2006. Activity data have been estimated using the data in the *Statistical Yearbook of Motor Vehicle Transport,* in a consistent estimation method from FY 1990 onward.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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.

***e) Source-specific Recalculations***

For gasoline passenger vehicle, gasoline light cargo truck, gasoline small cargo truck and diesel regular cargo truck, emission factors for $CH_4$ and $N_2O$ are revised by enforcement of the New Long-term Regulation for exhaust gas (from FY 2005). As a result, emissions for 2005 and 2006 are revised.

***f) Source-specific Planned Improvements***

For some types of vehicle, it is needed to discuss whether more suitable emission factors (i.e., those that are more representative of Japan's circumstances) should be established on the basis of actual measurements, because the default values presented in the *Revised 1996 IPCC Guidelines* and *Good Practice Guidance (2000)* are currently used.

### 3.2.4.2.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***

Emissions were calculated by multiplying the distance traveled per type of natural gas-powered vehicle by the emission factor for the type of vehicle.

### ●*Emission Factors*

Methane Emission factors for natural gas-powered light cargo trucks, small cargo trucks, light vehicle and passenger vehicle were determined using JAMA data and the same method used for the same type of gasoline or diesel powered vehicles.

Methane and nitrous oxide emission factors for regular cargo trucks and nitrous oxide emission factors for the vehicles mentioned above were determined using the average of the emission factors established for each travel speed category based on the actual measurements taken in Japan, 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).

In the absence of actual measurement data in Japan, emission factors for bus and special vehicles were determined by adjusting the emissions factors for small and regular cargo trucks as necessary, taking the characteristics of each type of vehicle into consideration.

Table 3-18 Methane and nitrous oxide emission factors for natural gas-powered vehicles

| Type | Calculation Method for Emission Factor | | Average Emission Factor | |
|---|---|---|---|---|
| | Methane | Nitrous Oxide | Methane [g-$CH_4$/km] | Nitrous Oxide [g-$N_2O$/km] |
| Small cargo truck | JAMA data | Determined based on actual measurements | 0.020 | 0.0002 |
| Passenger vehicle | JAMA data | Used the emission factors for small cargo truck, taking the specifications of each type of vehicle into account. | 0.013 | 0.0002 |
| light passenger vehicle, light cargo truck | JAMA data | | 0.013 | |
| Regular cargo truck | Determined based on actual measurements | | 0.366 | 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 regular cargo trucks, taking travel patterns of natural gas-powered special-purpose vehicles into consideration. | | 0.414 | 0.0145 |
| Bus | Determined from the emission factor for regular cargo truck which was adjusted by the ratio of equivalent inertia weight, taking vehicle weight into consideration. | | 1.098 | 0.0384 |

### ●*Activity Data*

Annual distance traveled per type of vehicle was determined by multiplying the number of natural gas-powered vehicles by the annual distance traveled per vehicle. The number of these vehicles was taken from the number of registered natural gas-powered vehicles per type in data compiled by the Japan Gas Association. For the annual distance traveled per type of vehicle, the value specific to the natural gas-powered vehicles could not be determined. As a result, the calculation of activity data used the annual distance traveled per vehicle for all fuel types which had been determined from the distance traveled per type of vehicle and the number of registered vehicles per type reported in the *Statistical Yearbook of Motor Vehicle Transport*.

Table 3-19 Annual distance traveled by natural gas-powered vehicles per type of vehicle.

| vehicle type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Passenger vehicle | 1,000 vehicle-km | 54 | 104 | 6,516 | 13,528 | 13,891 | 14,110 |
| Bus | 1,000 vehicle-km | 0 | 1,860 | 18,743 | 53,936 | 58,650 | 61,444 |
| Truck | 1,000 vehicle-km | 91 | 2,459 | 77,394 | 384,460 | 459,274 | 512,957 |
| Small cargo truck | 1,000 vehicle-km | 184 | 8,088 | 32,426 | 57,045 | 62,118 | 67,137 |
| Light vehicle | 1,000 vehicle-km | 0 | 498 | 19,217 | 68,750 | 77,266 | 85,284 |
| Garbage vehicle | 1,000 vehicle-km | 0 | 300 | 6,955 | 38,816 | 43,664 | 47,039 |

***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 $CH_4$ and $N_2O$ in common. The uncertainty assessment methods are summarized in Annex 7.

●***Time-series Consistency***

Emission factors were used same values from FY 1990 to FY 2007. Activity data were estimated by using the data in the *Statistical Yearbook of Motor Vehicle Transport* and the *Natural Gas Mining Association Data*, in the same estimation method consistently from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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.

***e) Source-specific Recalculations***

No recalculations were performed.

***f) Source-specific Planned Improvements***

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

### 3.2.4.2.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***

Emissions from motorcycles were estimated based on the method developed in Japan by the Ministry of Environment for the estimation of emissions from vehicles not subject to the PRTR (Pollutant Release and Transfer Register) Program. The emissions were calculated for two emission sources of

"Hot start" and "Increment for cold start", using the equations below. For details of the calculation method, see the *Greenhouse Gases Estimation Methods Committee Report – Transportation* (February, 2006).

| |
|---|
| *Methane and nitrous oxide emissions from hot-starting of motorcycles*<br>= Emission factor for vehicle-km per type of motorcycle × Total annual distance traveled by motorcycles per type |

| |
|---|
| *Methane emissions from increment at cold starting of motorcycles*<br>= Emission factor per start per type × Number of engine start-ups per year by each type of motorcycle |

●***Emission Factors***

➢ ***Hot start***

The THC (Total Hydro Carbon) emission factor for hot starts, derived from the actual measurement data in Japan, was multiplied by the ratio of the methane emission factor to the THC emission factor, obtained from actual measurements. The THC emission factors for motorcycles were established for each category of 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 nitrous oxide, the default emission factor for *US Motorcycles/European Motorcycles* given in the *Revised 1996 IPCC Guidelines* [0.002(g$N_2O$/km)]is used.

➢ ***Increment for cold start***

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

Table 3-20 $CH_4$ emission factors for motorcycles

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| two-wheel vehicle (hot start) | Small motor vehicle: first kind (travel speed 15-20km) | $gCH_4$/km | 0.111 | 0.111 | 0.094 | 0.055 | 0.048 | 0.044 |
| | (travel speed 20-25km) | $gCH_4$/km | 0.097 | 0.097 | 0.082 | 0.047 | 0.041 | 0.037 |
| | (travel speed 25-30km) | $gCH_4$/km | 0.097 | 0.097 | 0.082 | 0.047 | 0.041 | 0.037 |
| | (travel speed 30-40km) | $gCH_4$/km | 0.113 | 0.113 | 0.096 | 0.058 | 0.051 | 0.047 |
| | (travel speed 40-50km) | $gCH_4$/km | 0.159 | 0.159 | 0.140 | 0.093 | 0.084 | 0.078 |
| | Small motor vehicle: second kind (travel speed 15-20km) | $gCH_4$/km | 0.124 | 0.124 | 0.111 | 0.056 | 0.046 | 0.038 |
| | (travel speed 20-25km) | $gCH_4$/km | 0.107 | 0.107 | 0.096 | 0.049 | 0.041 | 0.034 |
| | (travel speed 25-30km) | $gCH_4$/km | 0.095 | 0.095 | 0.086 | 0.045 | 0.038 | 0.032 |
| | (travel speed 30-40km) | $gCH_4$/km | 0.084 | 0.084 | 0.076 | 0.041 | 0.035 | 0.030 |
| | (travel speed 40-50km) | $gCH_4$/km | 0.084 | 0.084 | 0.076 | 0.041 | 0.035 | 0.030 |
| | (travel speed 50-60km) | $gCH_4$/km | 0.084 | 0.084 | 0.076 | 0.041 | 0.034 | 0.029 |
| | (travel speed 60-80km) | $gCH_4$/km | 0.008 | 0.008 | 0.008 | 0.007 | 0.007 | 0.007 |
| | Light two-wheel vehicle (travel speed 15-20km) | $gCH_4$/km | 0.245 | 0.245 | 0.204 | 0.084 | 0.068 | 0.055 |
| | (travel speed 20-25km) | $gCH_4$/km | 0.212 | 0.212 | 0.177 | 0.073 | 0.060 | 0.049 |
| | (travel speed 25-30km) | $gCH_4$/km | 0.188 | 0.188 | 0.157 | 0.066 | 0.054 | 0.044 |
| | (travel speed 30-40km) | $gCH_4$/km | 0.161 | 0.161 | 0.134 | 0.056 | 0.046 | 0.038 |
| | (travel speed 40-50km) | $gCH_4$/km | 0.133 | 0.133 | 0.111 | 0.047 | 0.039 | 0.032 |
| | (travel speed 50-60km) | $gCH_4$/km | 0.111 | 0.111 | 0.092 | 0.039 | 0.032 | 0.027 |
| | (travel speed 60-80km) | $gCH_4$/km | 0.085 | 0.085 | 0.071 | 0.030 | 0.025 | 0.020 |
| | Small two-wheel vehicle (travel speed 15-20km) | $gCH_4$/km | 0.182 | 0.182 | 0.167 | 0.092 | 0.078 | 0.068 |
| | (travel speed 20-25km) | $gCH_4$/km | 0.160 | 0.160 | 0.147 | 0.081 | 0.069 | 0.059 |
| | (travel speed 25-30km) | $gCH_4$/km | 0.143 | 0.143 | 0.132 | 0.073 | 0.062 | 0.053 |
| | (travel speed 30-40km) | $gCH_4$/km | 0.124 | 0.124 | 0.113 | 0.063 | 0.054 | 0.047 |
| | (travel speed 40-50km) | $gCH_4$/km | 0.101 | 0.101 | 0.093 | 0.053 | 0.046 | 0.040 |
| | (travel speed 50-60km) | $gCH_4$/km | 0.080 | 0.080 | 0.074 | 0.044 | 0.038 | 0.034 |
| | (travel speed 60-80km) | $gCH_4$/km | 0.049 | 0.049 | 0.046 | 0.029 | 0.026 | 0.024 |
| Gasoline two-wheel vehicle (cold start) | Small motor vehicle: first kind controlled by regulation | $gCH_4$/number of time | | | 0.014 | 0.014 | 0.014 | 0.014 |
| | Small motor vehicle: first kind uncontrolled by regulation | $gCH_4$/number of time | 0.039 | 0.039 | 0.039 | 0.038 | 0.039 | 0.039 |
| | Small motor vehicle: second kind controlled by regulation | $gCH_4$/number of time | | | 0.018 | 0.018 | 0.018 | 0.018 |
| | Small motor vehicle: second kind uncontrolled by regulation | $gCH_4$/number of time | 0.012 | 0.012 | 0.012 | 0.008 | 0.012 | 0.012 |
| | Light two-wheel vehicle controlled by regulation | $gCH_4$/number of time | | | 0.028 | 0.028 | 0.028 | 0.028 |
| | Light two-wheel vehicle uncontrolled by regulation | $gCH_4$/number of time | 0.016 | 0.016 | 0.016 | 0.015 | 0.015 | 0.015 |
| | Small two-wheel vehicle controlled by regulation | $gCH_4$/number of time | | | 0.029 | 0.029 | 0.029 | 0.029 |
| | Small two-wheel vehicle uncontrolled by regulation | $gCH_4$/number of time | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 | 0.043 |

● ***Activity Data***

➢ ***Hot start***

Based on the motorcycle operation data in the *Road Transport Census*, 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 the determination of the activity data for this source, the rate of reduction 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 for 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><br>= (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, default values given in the *Good Practice Guidance (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 CH4 and 71% for N2O. The uncertainty assessment methods are summarized in Annex 7.

**●*Time-series Consistency***

Emission factors were used same values from FY 1990 to FY 2007. Activity data were estimated using the data in the *Statistical Yearbook of Motor Vehicle Transport* and Natural Gas Mining Association data, in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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.

### *e) Source-specific Recalculations*

Emission factors for $CH_4$ and $N_2O$ are provided responding to the new exhaust gas regulations for motorcycles (Enforcement in FY 2006). Hence, the emissions for $CH_4$ and $N_2O$ of FY 2006 are revised.

### *f) Source-specific Planned Improvements*

- There is a need to stock much more the data of annual distance traveled per type of vehicle in order to set more precise emission factors than the actual condition.
- To set much more accurate activity data, the data from four-wheeled vehicles is needed to be replaced with the data from two-wheeled vehicles.

## 3.2.4.3. 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 locomotives that use light oil. In addition, there are small amounts of emissions from coal-fired steam locomotives.

### *b) Methodological Issues*

**●*Estimation Method***

This source of emissions is not a key source category, and emissions were calculated by multiplying the default emission factor given in the *Revised 1996 IPCC Guidelines* by fuel consumption on a calorific basis.

The *Good Practice Guidance (2000)* does not provide a decision tree for a calculation method for this source.

| |
|---|
| <u>*Methane and nitrous oxide emissions from diesel locomotives*</u><br>= Emission factor for diesel engines in railways × Annual consumption of light oil by diesel locomotives |

| |
|---|
| <u>*Methane and nitrous oxide emissions from steam locomotives*</u><br>= Emission factor for coal in rail transportation × Annual consumption of coal by steam locomotives |

### ●*Emission Factors*

For emission factors for diesel-powered locomotives, the default value shown in the *Revised 1996 IPCC Guidelines* under *Diesel engines – Railways* was used after the conversion to a per-liter value using the calorific value of light oil.

For emission factors for steam locomotives, the default value shown in the *Revised 1996 IPCC Guidelines* under *Coal – Railways* was used after the conversion to a per-weight value using the calorific value of imported steam coal.

The following table gives the default values from the *Revised 1996 IPCC Guidelines*.

Table 3-21 Default values for railway emission factors

| | Diesel Locomotives | Steam Locomotives |
|---|---|---|
| Methane emission factor | 0.004 [g-$CH_4$/MJ] | 10 [kg-$CH_4$/TJ] |
| Nitrous oxide emission factor | 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 light oil by diesel locomotives, light oil consumption in the railway sector shown in the *General Energy Statistics* compiled by the Agency for National Resources and Energy was used as the activity data.

Coal consumption by steam locomotives was considered to be the value shown in the Statistical Yearbook of Railway Transport (Ministry of Land, Infrastructure, Transport and Tourism) in the table "*Cost of Consumption of Operating Electricity, Fuel and Oil*" under *Cost under the Other fuel – Cost.* The cost-based value was divided by the coal price for each year (for imported steam coal) shown in the *Directory of Energy and Economic Statistics* to estimate the coal consumption.

The default emission factor given in the *Revised 1996 IPCC Guidelines*, etc., is expressed in net calorific value. Therefore, in order to apply this emission factor, the calorific value, which is generally expressed as gross calorific value in Japan's energy statistics, is converted into the net calorific value.

Table 3-22 Activity Data associated with emissions from railways

| Fuel type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Diesel oil | kl | 356,224 | 313,235 | 269,711 | 248,211 | 248,211 | 248,211 |
| Coal | kt | 17 | 19 | 28 | 13 | 11 | 9 |

### 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 from diesel-engine locomotive, 10% given in the *Statistical Yearbook of Railway Transport*, was applied. For the uncertainty of activity data from coal-fired steam locomotives, 105% aggregated by the values given in the *Statistical Yearbook of Railway Transport* and the *Directory of Energy and Economics Statistics*, was applied. As a result, the uncertainties of the emissions were determined to be 11% for $CH_4$ and $N_2O$ from diesel-engine locomotives and 101% for $CH_4$ and $N_2O$ from coal-fired steam locomotives. The uncertainty assessment methods are summarized in Annex 7.

**●*Time-series Consistency***

Emission factors were used same values from FY 1990 to FY 2007. The data given in the *General Energy Statistics* for diesel-engine locomotives were used as a activity data consistently from FY 1990 to FY2007. Activity data for coal-fired steam locomotives were calculated using the data in the *Statistical Yearbook of Railway Transport* and the *Directory of Energy and Economics Statistics,* in 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 *Good Practice Guidance (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.

### e） *Source-specific Recalculations*

For emissions of $CH_4$ and $N_2O$ from coal-fired steam locomotives, activity data (coal consumption) of FY 2006 are revised responding to the publication of the *Statistical Yearbook of Railway Transport of FY 2006*. As a result, emissions for $CH_4$ and $N_2O$ of FY 2006 are revised.

### f） *Source-specific Planned Improvements*

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

## 3.2.4.4. 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 methane and nitrous oxide through the use of light oil and fuel oils A, B and C during their navigation.

### b） *Methodological Issues*

**●*Estimation Method***

Emissions were calculated using the default values for methane and nitrous oxide given in the *Revised 1996 IPCC Guidelines*, in accordance with Decision Tree of the *Good Practice Guidance (2000)*

(Page 2.52, Fig. 2.6).

| |
|---|
| Methane and nitrous oxide emissions associated with navigation of domestic vessels<br>= Emission factors for light oil and fuel oils A, B and C relating to domestic vessels × Consumption of each type of fuel by domestic vessels |

● ***Emission Factors***

The default values for Ocean-Going Ships (diesel engines) given in the *Revised 1996 IPCC Guidelines* were converted to emission factor per liter using the calorific value for each type of fuel (gas oil, heating oils A, B and C). The following gives the default values from the *Revised 1996 IPCC Guidelines*.

Table 3-23 Default emission factors for navigation

| | Value |
|---|---|
| Methane Emission Factor | 0.007 [g-$CH_4$/MJ] |
| Nitrous Oxide Emission Factor | 0.002 [g-$N_2O$/MJ] |

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

● ***Activity Data***

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

The default emission factor given in the *Revised 1996 IPCC Guidelines*, etc., is expressed in net calorific value. Therefore, in order to apply this emission factor, gross calorific value, which is generally adopted in Japan's energy statistics, is first converted into net calorific value, and then it is used for the conversion to the liter-based emissions factor.

Table 3-24 Activity Data associated with emissions from ships

| Fuel type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Diesel oil | 1000kl | 133 | 208 | 204 | 195 | 172 | 172 |
| Heavy oil (A) | 1000kl | 1,602 | 1,625 | 1,728 | 1,318 | 1,217 | 1,128 |
| Heavy oil (B) | 1000kl | 526 | 215 | 152 | 63 | 41 | 42 |
| Heavy oil (C) | 1000kl | 2,446 | 3,002 | 3,055 | 2,872 | 2,888 | 2,884 |

### *c) Uncertainties and Time-series Consistency*

● ***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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 64% for $CH_4$ and 71% for $N_2O$. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emission factors were used same values from FY 1990 to FY 2007. The activity data given in the *General Energy Statistics* were used as the activity data for navigation consistently from FY 1990 to FY2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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.

### *e) Source-specific Recalculations*

No recalculations were performed.

### *f) Source-specific Planned Improvements*

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

## 3.2.5. Other Sources (1.A.4)

### *a) Source/Sink Category Description*

This category provides the estimation methods for $CO_2$ emissions from Commercial /Institutional (1.A.4.a), Residential (1.A.4.b) and Agriculture / Forestry / Fisheries (1.A.4.c).

### *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 as well energy industry (1.A.1).

Activity data for each sub-category are the values for final energy consumption in Commercial/Institutional (#7500), Residential (#7100), and Agriculture/Forestry/Fisheries (#6110) sector in *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 3-25 Correspondence between sectors of Japan's Energy Balance Table and 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, ResCom & others (Commercial & Others) | #9800 |
| | 1A4b | Residential | Final Energy Consumption, Residential | #7100 |
| | | | Non-Energy, ResCom & others (Residential) | #9800 |
| | 1A4c | Agriculture/Forestry/Fisheries | Final Energy Consumption, Agruculture, Forestry & Fishery | #6110 |
| | | | Non-Energy, Non-Manufacturing Industry (Agruculture, Forestry & Fishery) | #9610 |

#### 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 *Good Practice Guidance (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. Details of the QA/QC activities are provided in Annex 6

#### e) Source-specific Recalculations

See Section 3.2.1 e).

#### f) Source-specific Planned Improvements

There are no major planned improvements in this source category.

### 3.2.6. Comparison of Sectoral and Reference Approaches

This comparison is documented and described in Annex 4.

### 3.2.7. 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 marine and air transportation.
Exclusion of emissions from bunker fuels used for international marine and air transport from the national totals has been reported in a memo item.

#### b) Methodological Issues

●***Estimation Method***

Emissions of carbon dioxide, methane and nitrous oxide from this source are derived by multiplying the consumption of each type of fuel handled by bonds by the emission factor.

●***Emission Factors***

**【$CO_2$】**

The emission factors used for carbon dioxide are the same as those for the energy sectors, fuel combustion ($CO_2$) in energy sectors (Refer to Section 3.2.1).

**【$CH_4$, $N_2O$】**

Default values given in the *Revised 1996 IPCC Guidelines* are used for methane and nitrous oxide emission factors.

Table 3-26 Emission factors for methane and nitrous oxide 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 | Heavy oil A | 0.007 [g $CH_4$/MJ] [c] | 0.002 [g $N_2O$/MJ] [c] |
| | Heavy oil B | 0.007 [g $CH_4$/MJ] [c] | 0.002 [g $N_2O$/MJ] [c] |
| | Heavy oil C | 0.007 [g $CH_4$/MJ] [c] | 0.002 [g $N_2O$/MJ] [c] |
| | Diesel oil | 0.007 [g $CH_4$/MJ] [c] | 0.002 [g $N_2O$/MJ] [c] |
| | 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. 〃 Table 1-52

c. 〃 Table 1-48

● ***Activity Data***

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 emissions of carbon dioxide, methane, and nitrous oxide 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 the international aviation and the marine transport.

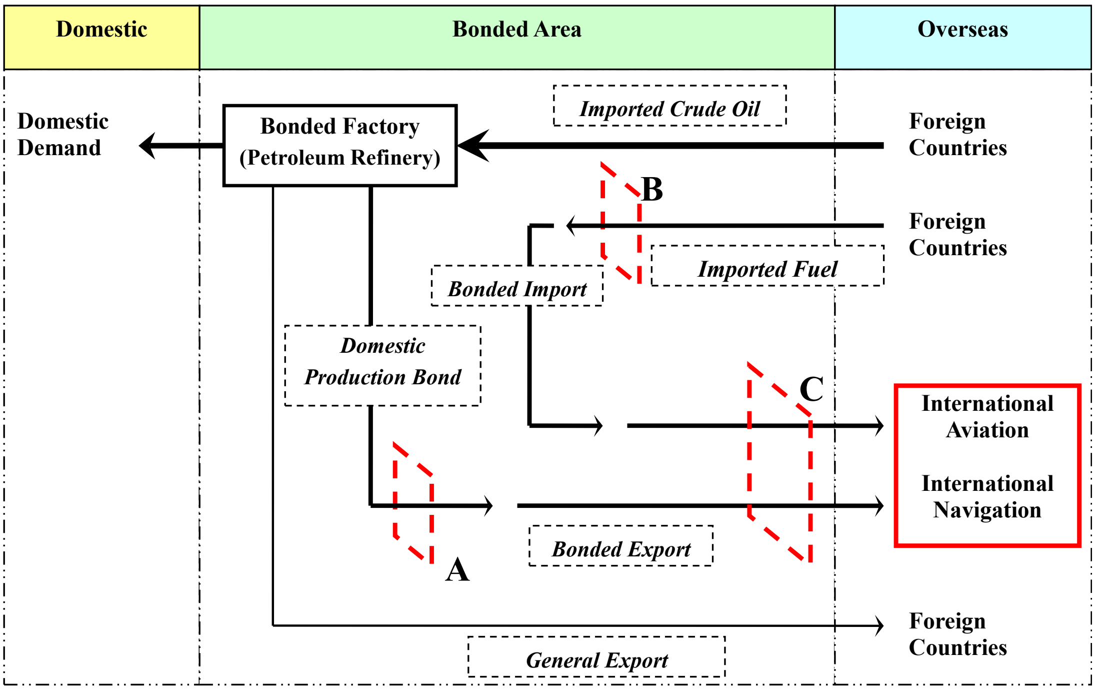


Figure 3-1 Activity data for international bunkers

It is assumed that jet fuel is used by aircraft, while heavy oil A, B, C, diesel oil and kerosene are used by vessels. Heavy oil A, B, and C are used for propulsion of international water-borne vessels. Diesel oil and kerosene are used only for fuels of private power generator (eg. 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)* is converted to a Joule-based data using the standard calorific values given in the Agency for Natural Resources and Energy's *General Energy Statistics*.

**【$CH_4$, $N_2O$】**

The *Revised 1996 IPCC Guidelines* provide a default emission factor that is based on net calorific values. Therefore, activity data in gross calorific values are converted to net calorific values by multiplying them by 0.95.

In addition, regarding activity data of $N_2O$ from an 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 identified by the Petroleum Association of Japan for nitrous oxide from aircraft (0.78 [g/cm$^3$]).

### c) Other issues

The desk review report in 2004 indicated that there was a significant difference between bunker AD reported in the CRF (table 1.C) and bunker consumption data reported to the International Energy Agency (IEA). The followings explain the causes for the difference.

➢ ***Data Update***

The ERT in 2004 used the following IEA energy balances for analysis.

- Data for 2000-2001: " ENERGY BALANCES OF OECD COUNTRIES 2000-2001」 II 94-95"
- Data for 2002-2003: " ENERGY BALANCES OF OECD COUNTRIES 2002-2003」 II 94-95"

After the publication of the data, it was found out that there were some errors in data of 2000 and 2001 submitted to IEA, including omission of full counting of imported bunker fuel and errors in the values of exported diesel oil. In March 2006, Japan reported the revision of these errors and the errors have been corrected since then.

➢ ***Difference of fuel types reported as "bunker"***

Up to Japan's national greenhouse gas inventories submitted in May 2004, Japan reported the bonded imports and exports of heavy oil A, B, and C as marine bunker. In IEA energy balance, marine bunker reported includes bonded diesel oil, kerosene and lubricant, other than bonded heavy oil A, B and C. This difference causes the variation between inventory data and IEA data.

Japan revised the estimation method in the inventory submitted in August 2004 and has reported bonded diesel oil and kerosene consumption as marine bunker since then[3].

➢ ***Errors of density and conversion factor***

Data for the IEA energy balance need to be reported in the metric-ton unit. Japan calculates and reports to IEA values in metric-ton by multiplying the volume of fuel combustion given in the *Yearbook of Mineral Resources and Petroleum Products Statistics* by the density of each fuel type given in the *information of petroleum*, Sekiyu –Tsushin. IEA converts the values in metric ton into tons of oil equivalent (TOE) by using conversion factors. Given that the values are expressed in net calorific-based value equivalent, one can judge that the conversion factors used in IEA are net calorific value.

Conversion of a unit to TOE by using information given in the inventory can be conducted by multiplying the volume of fuel consumption by gross calorific-based values.

This difference in the conversion process causes the variation between IEA energy balance and Japans energy statistics for inventory preparation.

**Glossary**

<u>Bonded Jet Fuel</u>

Under the Tariff Law, aircrafts (Japanese and non-Japanese) flying international routes are deemed to be "overseas return aircraft", 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

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[3] Lubricant is not included because lubricant is not combusted by use.

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 tariffs and the petroleum tax are waived. The foregoing is termed as "bonded fuel oil".

Bonded Export

The demand for fuel supplied to aircrafts (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 aircrafts while fuel oil is supplied to ships. Of these bonded demand, the fuel supplied from products that was produced from crude oil is counted as bonded exports by the Ministry of Economy, Trade and Industry.

Bonded imports (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 imports by the Ministry of Economy, Trade and Industry.

### 3.2.8. 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) in *General Energy Statistics* was deducted from the total energy consumption, because these amounts of fuel was used as feedstocks without combustion and oxidation process.

The Non-energy category is used provided that the use corresponds to either of the following two requirements: (1) Consumption which can be confirmed as clearly being employed for non-energy uses by official statistics, such as surveys of feedstocks inputs according to *Current Survey of Energy Consumption* which is the data source of *General Energy Statistics*; and (2) Products which are from the outset produced for the purpose of non-energy use.
(However, that portion which is confirmed from official statistics such as *Current Survey of Energy Consumption* as having been employed for energy uses is treated as energy consumption and excluded from non-energy use.)

$CO_2$ emissions from combustion and oxidation in the process of production, use and abandonment of the amount of feedstocks and non-energy use which were deducted from 1.A are separately reported in the following sectors.

- Ammonia Production（2.B.1）
- Silicon Carbide Production（2.B.4）
- Calcium Carbide Production（2.B.4）
- Ethylene Production（2.B.5）
- Use of Electric Arc Furnaces in Steel Production（2.C.1）
- Wastes Incineration (Simple Incineration) (waste oil and waste plastics)（6.C）

- ♦ Emissions from the Decomposition of Petroleum-Derived Surfactants（6.D）

### 3.2.9. $CO_2$ capture from flue gases and subsequent $CO_2$ storage

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

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

The Fugitive Emissions sector 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 methane 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 2007, GHG emissions from fugitive emission from fuels were 454 Gg-$CO_2$ and accounted for 0.03 % of the Japan's total GHG emissions from the energy sector. The emissions had decreased by 85 % compared to 1990.

### 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 methane that formed during the coalification process. Most will have been naturally released from the ground surface before mine development, but mining releases the methane remaining in coal beds into the atmosphere.

The number of operational coal mines in Japan decreased and coal production has decreased greatly as well. As a result, the amount of the $CH_4$ emissions from coal has shown a yearly decrease.

Furthermore, the coal mining practices have changed recently, resulting in the decreasing trend of 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.

***b） Methodological Issues***

●***Estimation Method***

➢ ***Mining Activities***

Emissions from mining activities were drawn from actual measurements obtained from individual coal mines, in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.72, Fig. 2.10).

➢ ***Post-Mining Activities***

Emissions from post-mining activities were calculated using the Tier 1 method, which uses default emission factors in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.73, Fig. 2.11).

● ***Emission Factors***

➢ ***Mining Activities***

The emission factor for mining activities was established by dividing the emissions of methane gas identified in a survey by Japan Coal Energy Center (J-COAL), by the production volume of coal from underground.

Table 3-27 Emission factors for mining activities – Underground mines

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | Reference |
|---|---|---|---|---|---|---|---|---|
| Coal Production of Underground Mines | kt | 6,775 | 5,622 | 2,364 | 738 | 745 | 617 | Surveyed by J-COAL |
| $CH_4$ Total Emissions | $1000m^3$ | 181,358 | 80,928 | 48,110 | 2,781 | 2,258 | 1,319 | Surveyed by J-COAL |
| $CH_4$ Total Emissions | Gg-$CH_4$ | 121.5 | 54.2 | 32.2 | 1.9 | 1.5 | 0.9 | =$CH_4$ [$1000m^3$] / 1000 X 0.67 [$Gg/10^6m^3$] |
| Emission Factor | kg-$CH_4$/t | 17.9 | 9.6 | 13.6 | 2.5 | 2.0 | 1.4 | $CH_4$ Total Emissions |

➢ ***Post-Mining Activities***

Due to the lack of data for emissions from post-mining activities in Japan, 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 methane, 0.67 (thousand t/$10^6$ $m^3$) at 20°C and 1 atmosphere.

● ***Activity Data***

➢ ***Mining Activities***

The $CH_4$ emissions for mining activities were given the emissions of methane gas identified in a survey by Japan Coal Energy Center (J-COAL).

➢ ***Post-Mining Activities***

The value used for activity data for underground mining and post-mining activities was derived by subtracting the open-cut 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 Japan Coal Energy Center.

Table 3-28 Trends in coal production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Total Coal Production | t | 7,980 | 6,317 | 2,974 | 1,249 | 1,351 | 1,280 |
| Surface Mines | t | 1,205 | 695 | 610 | 511 | 607 | 663 |
| Underground Mines | t | 6,775 | 5,622 | 2,364 | 738 | 745 | 617 |

### c） Uncertainties and Time-series Consistency

● ***Uncertainties***

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.

Uncertainty for $CH_4$ emissions from post-mining activities was 5%, which is the value of the default data in *Good Practice Guidance (2000)*. A summary of uncertainty assessment methods is provided in Annex 7.

● ***Time-series Consistency***

The emissions data for $CH_4$ from mining activities in underground mines have been derived from *Japan Coal Energy Center* statistics consistently since FY 1990. Coal production and the production on surface mines were provided by the *Japan Coal Energy Center* from FY 1990 to FY 2000; thereafter they have been provided by the *Yearbook of Production, Supply and Demand of Petroleum*, because the data survey by the *Japan Coal Energy Center* is no longer conducted. Total coal production data from both of these sources have been used in a consistent estimation method since 1990.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.

## 3.3.1.1.b. Surface Mines (1.B.1.a.ii.)

### *a） Source/Sink Category Description*

This category provides the estimation methods for fugitive emissions of $CH_4$ occur during the coal mining and post-mining activities on surface mines.

Although a reporting column is provided for carbon dioxide emissions associated with coal mining, in the absence of a default emission factor, emissions from this source were reported as “NE”. Coal mining exists in Japan, and, depending on the carbon dioxide concentration in the coal being mined, the carbon dioxide may be released into the atmosphere during mining activity. Although it is believed that coal beds in Japan do not contain carbon dioxide 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 as well of a default value for carbon dioxide emissions associated with coal mining, emissions from this source are not reported.

### *b） Methodological Issues*

● ***Estimation Method***

➢ ***Mining Activities***

Methane emissions were calculated using the Tier 1 method and the default emission factor in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.71, Fig. 2.9).

➢ ***Post-Mining Activities***

Methane emissions were calculated using the Tier 1 method and the default emission factor in accordance with Decision Tree or the *Good Practice Guidance (2000)* (Page 2.73, Fig. 2.11). (Refer to *1B1-2008.xls* for the calculation process.)

Both were calculated by multiplying the amount of coal mined from open-cut mining by the relevant emission factors.

● ***Emission Factors***

➢ ***Mining Activities***

A value (0.77 [kg-$CH_4$/t-coal]) was used as the 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 methane at one atmospheric pressure and 20°C (0.67 [Gg/$10^6 m^3$]).

➢ ***Post-Mining Activities***

A value (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 methane at 1 atmospheric pressure and 20°C (0.67 [Gg/$10^6 m^3$]).

● ***Activity Data***

The figure for the open-cut production 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 and the data provided by the Japan Coal Energy Center were used as the activity data for mining and post-mining activities (Table 3-28).

### c) Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties for emission factors were applied 200% of default data indicated in the *Good Practice Guidance (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 200% for $CH_4$ from surface mines. Summary of uncertainty assessment methods are provided in Annex 7.

● ***Time-series Consistency***

Coal production and the production for surface mines were provided by the *Japan Coal Energy Center* from FY 1990 to FY 2000; thereafter they have been provided by the *Yearbook of Production, Supply and Demand of Petroleum*, because the data survey by the *Japan Coal Energy Center* is no longer conducted. Total coal production data from both of these sources have been used in a consistent estimation method since 1990.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.

#### 3.3.1.2. 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 emission of carbon dioxide, methane or nitrous oxide cannot be denied. However, as no actual measurements have been taken, however, it is not presently possible to calculate emissions. Carbon dioxide, methane and nitrous oxide emissions associated with the conversion to solid 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 $N_2O$ occur during the exploratory drilling of oil and gas fields and pre-production tests.

***b) Methodological Issues***

●***Estimation Method***

Carbon dioxide, methane and nitrous oxide emissions associated with oil exploration and pre-production testing was calculated using the Tier 1 Method in accordance with the Decision Tree of *Good Practice Guidance (2000)*. Emissions were calculated by multiplying the number of exploratory 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 *Good Practice Guidance (2000)* for drilling and testing wells were used.

Table 3-29 Emission factors for exploratory and testing wells [Gg/number of wells]

| | $CH_4$ | $CO_2$ | $N_2O$ |
|---|---|---|---|
| Drilling | $4.3\times10^{-7}$ | $2.8\times10^{-8}$ | 0 |
| Testing | $2.7\times10^{-4}$ | $5.7\times10^{-3}$ | $6.8\times10^{-8}$ |

Source: Good Practice Guide (2000), p. 2.86, Table 2.16

●***Activity Data***

➢ ***Drilling***

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

➢ ***Testing***

It was 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 are conducted, not all wells are successful. For that reason, the number of wells tested for oil and gas used the median values of the number of exploratory wells and the number of successful wells shown in the *Natural Gas Data Year Book.*

For both oil and gas, the calendar year values were used as the data for the most recent year.

Table 3-30 Trends in the number of exploratory wells and those tested for oil and gas

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Number of Wells Drilled | wells | 8 | 7 | 7 | 10 | 7 | 6 |
| Number of Wells Succeeded | wells | 1 | 3 | 4 | 5 | 2 | 0 |
| Number of Wells Tested | wells | 5 | 5 | 6 | 8 | 5 | 3 |

***c） Uncertainties and Time-series Consistency***

●***Uncertainties***

Because all emission factors for exploration of oil and natural gas were the default values in *Good Practice Guidance (2000),* the uncertainties for emission factors were assessed based on default values (25%) described in *Good Practice Guidance (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. 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 are provided in Annex 7.

●***Time-series Consistency***

Emission factors have used consistent values from FY 1990 to FY 2007. Activity data have been calculated by using annual data from the *Natural Gas Data Year Book* and a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.

### 3.3.2.1.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 $CH_4$ occur during production of crude oil, as well as when measuring instruments are lowered into oil wells during inspection of operating oil fields.

***b） Methodological Issues***

●***Estimation Method***

Emissions relating to fugitive emissions from petroleum production and servicing of oilfield production wells were calculated using the Tier 1 method in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.81, Fig. 2.13). 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 *Good Practice Guidance (2000)* was used for the emission factor of fugitive emissions from petroleum production. (The median of the default values was used for methane).

Table 3-31 EF for fugitive emissions from petroleum production [Gg/$10^3$kl]

| | | $CH_4$ 1) | $CO_2$ | $N_2O$ 2) |
|---|---|---|---|---|
| Conventional Oil | Fugitive emissions | $1.45\times10^{-3}$ | $2.7\times10^{-4}$ | 0 |

Source: *GPG (2000)* Table 2.16

1) The default value is $1.4\times10^{-3}$ – $1.5\times10^{-3}$

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

➢ ***Servicing***

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

Table 3-32 EF for fugitive emissions from servicing of petroleum production wells

[Gg/number of wells]

| | $CH_4$ | $CO_2$ | $N_2O$ 1) |
|---|---|---|---|
| Production Well (Servicing) | $6.4\times10^{-5}$ | $4.8\times10^{-7}$ | 0 |

Source: *GPG (2000)* Table 2.16

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

● ***Activity Data***

➢ ***Production***

The values for production of crude oil in Japan given in the METI's *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* were used as the 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 for the entire time series, the total fugitive emissions from servicing of oil and natural gas wells are reported in the subcategory *1.B.2.b.i. Exploration* and is so, servicing of oil wells is included there.

### *c) Uncertainties and Time-series Consistency*

● ***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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 $CO_2$ and for $CH_4$. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using 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,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.

### 3.3.2.1.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 $CH_4$ occur during the transportation of crude oil and condensate through pipelines, tank trucks, and tank cars to refineries.

#### b） Methodological Issues

**●*Estimation Method***

Emissions relating to fugitive emissions associated with transport were calculated using the Tier 1 method in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.81, Fig. 2.13). Emissions were calculated by multiplying the amount of crude oil or condensate production by the emission factors. Crude oil for sea transport is carried out entirely by pipeline, and is not expected to generate any fugitive emissions. Land transport includes a number of methods, including pipeline, trucks, and tanker rail cars, but it is difficult to differentiate them statistically. For that reason, it has been assumed that all of the produced oil is transported by tanker trucks or rail cars in calculations.

**●*Emission Factors***

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

Table 3-33 Emission factors for transportation of crude oil and condensate [Gg/$10^3$kl]

| | $CH_4$ | $CO_2$ | $N_2O$ 1) |
|---|---|---|---|
| Transportation of crude oil | $2.5\times10^{-5}$ | $2.3\times10^{-6}$ | 0 |
| Transportation of condensate | $1.1\times10^{-4}$ | $7.2\times10^{-6}$ | 0 |

Source: *GPG (2000)* Table 2.16
1) Excluded from calculations, as the default value is 0 (zero)

**●*Activity Data***

The values for production of oil in Japan given in the METI's *Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke* and the *Yearbook of Mineral Resources and Petroleum Products Statistics* were used as the activity data for fugitive emissions from transport.

Table 3-34 Production of crude oil and condensate in Japan

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Oil Production excluding condensate | kl | 420,415 | 622,679 | 385,565 | 370,423 | 329,234 | 334,467 |
| Condensate Production | kl | 234,111 | 242,859 | 375,488 | 540,507 | 575,898 | 644,525 |
| Oil Production | kl | 654,526 | 865,538 | 761,053 | 910,930 | 905,132 | 978,992 |

### c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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 $CO_2$ and for $CH_4$.The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using 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,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.

## 3.3.2.1.d. Refining / Storage (1.B.2.a.iv.)

### a) Source/Sink Category Description

This category provides the estimation methods for fugitive emissions of $CH_4$ occur when crude oil is refined or stored at oil refineries.

$CO_2$ emissions from this source were reported as “NE”.   Refining / Storage activities exist in Japan and extremely small amount of $CO_2$ may be released into the atmosphere from the activities if $CO_2$ is included in crude oil. Because there is no examples of actual measurements of the $CO_2$ content of crude oil as well as a default value, $CO_2$ emissions from this source were not estimated.

### b) Methodological Issues

● ***Estimation Method***

➢ ***Oil Refining***

Emissions relating to fugitive emissions from refining were calculated using the Tier 1 method in accordance with Decision Tree the *Good Practice Guidance (2000)* (Page 2.82, Fig. 2.14).

➢ ***Oil Storage***

Emissions relating to fugitive emissions from storage should be calculated using the Tier 1 method in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.82, Fig.2.14), but as the country-specific emission factor is available for this emissions source, it was applied to the inventories instead.

●***Emission Factors***

➢ ***Oil Refining***

With respect to the emissions factors for the fugitive emissions during the refining processes, the amount of methane emitted during crude oil refining processes was considered to be negligible because fugitive emission of methane was unlikely 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 3-35 Emission factor during refining of crude oil

| Emission Factor [kg-$CH_4$/PJ] | |
|---|---|
| Oil Refining | 90[1)] |

Source: *Revised1996 IPCC Guidelines*, Volume 3 Table1-58
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 fugitive methane emissions are considered to be very small. If fugitive methane 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 methane emissions would be small.

The Petroleum Association of Japan has conducted experiments relating to the evaporation of methane from tank walls by modeling the floating-roof tank to calculate estimates of methane emissions.

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

Table 3-36 Assumptions for calculation of emission factor during oil storage

| Methane 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 value used for activity data during refining and storing was the converted net calorific values of NGL and refined crude oil in petroleum refining industry taken from the *General Energy Statistics* compiled by the Agency for Natural Resources and Energy.

Table 3-37 Amount of crude and NGL refined in Japan

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Oil and LGL Refined | PJ:NCV | 7,732 | 8,907 | 8,898 | 8,822 | 8,456 | 8,587 |

### c) *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The uncertainties for emission factors were applied 25% of default data indicated in the *Good Practice Guidance (2000)*. The uncertainty for activity data was evaluated to be 0.9% by combing the uncertainty of crude oil and LNG indicated in the *General Energy Statistics*. As a result, the uncertainties for emissions were determined to 25% for $CH_4$ emissions from the source. Summary of uncertainty assessment methods are provided in Annex 7.

● ***Time-series Consistency***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using annual data from the *General Energy Statistics,* in a consistent estimation method from FY 1990 to FY 2007.

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

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

### e) *Source-specific Recalculations*

The emissions in FY 2005 were recalculated because of the revision of the values in FY 2005 reported in the *General Energy Statistics* which were used as the basis for activity data in the category of 1.B.2.a.iv.

### 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 carbon dioxide and methane are dissolved, it is conceivable that either or both will be emitted as a result of the relevant activity. The level of carbon dioxide or methane emitted by the activity is probably negligible, in light of the composition of the petroleum products, but because there are no examples of measurement of the carbon dioxide or methane content of petroleum products, it is not currently possible to calculate emissions. Emissions were reported as “NE” in the absence of the 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 is test drillings of oil and gas fields in Japan, and it is conceivable that the activity could give rise to emissions of carbon dioxide, methane, or nitrous oxide. It is difficult, however, to distinguish between oilfields and gas fields prior to test drilling, 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 $CO_2$ and $CH_4$ emissions from fugitive emissions of the production of natural gas and processing of natural gas, such as adjusting its constituent elements, and servicing natural gas production wells.

#### *b） Methodological Issues*

●***Estimation Method***

Fugitive emissions of the production of natural gas and processing of natural gas, such as adjusting its constituent elements, and servicing natural gas production wells was calculated using the Tier 1 method, and in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 2.80, Fig. 2.12).

Fugitive emissions during natural gas production and conditioning processes were estimated by multiplying the amount of natural gas production by their respective emission factors. 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 *Good Practice Guidance (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 methane).

Table 3-38 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 | $2.75\times10^{-3}$ | $9.5\times10^{-5}$ | 0 |

Source: *GPG (2000)* Table 2.16
1) The default values are $2.6\times10^{-3}$ – $2.9\times10^{-3}$
2) Excluded from calculations, as the default value is 0 (zero)

➢ ***Processing***

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

Table 3-39 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) | $8.8\times10^{-4}$ | $2.7\times10^{-5}$ | 0 |

Source: *GPG (2000)* Table 2.16
1) The default values are $6.9\times10^{-4}$ – $10.7\times10^{-4}$
2) Excluded from calculations, as the default value is 0 (zero)

➢ ***Servicing***

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

Table 3-40Emission factors during servicing of natural gas production wells

[Gg/number of wells]

| | $CH_4$ | $CO_2$ | $N_2O$ 1) |
|---|---|---|---|
| Production Well (Servicing) | $6.4\times10^{-5}$ | $4.8\times10^{-7}$ | 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 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 the 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.

Table 3-41 Natural gas production and the number of producing and capable wells

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Natural Gas Production | $10^6 m^3$ | 2,066 | 2,237 | 2,499 | 3,140 | 3,408 | 3,729 |
| Number of Producing and Capable Wells | wells | 1,230 | 1,205 | 1,137 | 1,115 | 1,126 | 1,099 |

### c) Uncertainties and Time-series Consistency

● ***Uncertainties***

As the uncertainty of emission factors for the $CO_2$ and $CH_4$ emissions from fugitive emissions of the production of natural gas, default values given in the *Good Practice Guidance (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 $CO_2$ and for $CH_4$.

As the uncertainty of emission factors for the $CO_2$ and $CH_4$ emissions from fugitive emissions of the processing of natural gas, default values given in the *Good Practice Guidance (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 27% for $CO_2$ and for $CH_4$.

The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emission factors have used consistent values from FY 1990 to FY 2007. Activity data have been calculated by using 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* and on the number of oil/natural gas wells from the *Natural Gas Data Year Book.* A consistent estimation method has been used from FY 1990 to FY 2007.

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

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

***e) Source-specific Recalculations***

The emissions in FY 2005 were recalculated because of the revision of the values in FY 2005 reported in the *Natural Gas Data Year Book* which were used as the basis for activity data in the category.

***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 are the release of gas when relocating and building pipelines, and the release of gas used to operate pressure regulators.

Emissions from $CO_2$ in this source are reported as “NA.” Approximately 90% of town gas is based on LNG and is free of carbon dioxide. 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 natural gas production plants before the gas is sent to pipelines, the natural gas provided by town gas suppliers likely contains hardly any $CO_2$. 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***

Total natural gas pipeline length 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 length of domestic natural gas pipeline over a 1-y period 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 to use a uniform emission factor that was set using FY2004 data for 1990 and subsequent years. Data were provided by the Japan Natural Gas Association.

***i) 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 with a gas meter or calculating it using means such as pipeline pressure when introducing the gas. These were calculated for each pipeline relocation and the annual cumulative total determined.

| |
|---|
| $CH_4$ emission amount = volume of pipe section with reduced pressure × pressure before reduction (absolute pressure) / atmospheric pressure (absolute pressure) × $CH_4$ content ($CH_4$ per $Nm^3$) |

### *ii) Gas Releases Due To Pipeline Installation*

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

### *iii) Release of Gas for Operating Pressure Regulators*

Calculated as follows from the amount of natural gas used in accordance with specifications of pressure regulators for reducing gas supply pressure.

| |
|---|
| $CH_4$ emission amount = amount used according to pressure regulator specifications × number of regulators installed × methane content ($CH_4$ per $Nm^3$) |

Table 3-42 FY2004 $CH_4$ emissions as a concomitant of natural gas transmission

| | Amount of gas used ($Nm^3$/day) | Number of work | Number of establishment | Amount of gas releases (k-$Nm^3$) | $CH_4$ conversion factor (t-$CH_4$/k$Nm^3$) | $CH_4$ 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 = $CH_4$ release amount / total pipeline length<br>＝759 t-$CH_4$ / 2090 km<br>＝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 the activity data of the length of natural gas pipeline laid.

Table 3-43 Length of natural gas pipeline installation

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Natural Gas Pipeline length | km | 1,984 | 2,195 | 2,434 | 2,721 | 2,903 | 2,987 |

### *c） Uncertainties and Time-series Consistency*

●***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (2000)* (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 $CH_4$. The uncertainty assessment methods are summarized in Annex 7.

●***Time-series Consistency***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using annual data from the *Natural Gas Data Year Book,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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*

The $CH_4$ emissions in conjunction with transmission of domestically produced natural gas are estimated as premise the full transmission of natural gas is sent to pipelines(1.B.2.b.iii.), however, there are some cases of the transmission of LNG is sent by tank lorry or rail recently. If sufficient data on $CH_4$ emissions from transmission of natural gas by the tank lorry and rail is obtained in the future, the possibilities of estimation methods for this category should 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.

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.

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 of emissions from town gas production.

Emissions from $CO_2$ in this source are reported as "NA.". More than 90% of town gas is based on

LNG and is free of carbon dioxide. 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 natural gas production plants before the gas is sent to pipelines, the natural gas provided by town gas suppliers likely contains hardly any $CO_2$. 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***

➢ ***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 *Good Practice Guidance* (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 city gas pipeline by the emission factor. $CH_4$ emissions from service pipes are calculated by multiplying the number of users by the emission coefficient.

**●*Emission Factors***

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

The emission factor was calculated by dividing emission of methane 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 FY1998 data was 905.41 (kg$CH_4$/PJ), while that calculated using FY2007 data was 264.07 (kg$CH_4$/PJ). The main reason for the emission factor change was the reduction in $CH_4$ emissions, which was due to 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 gradually implemented, 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 major change in the emission factor for the time being. Therefore, the FY2007 emission factor value will be kept the same for FY2008 and subsequent years.

➢ ***Town Gas Supply Networks***

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 3-44. 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 y, while that for service pipes was set using the $CH_4$ amount emitted from 1000 users' homes during 1 y.

Table 3-44 $CH_4$ emissions from town gas pipelines and emission factors (Established by FY2007 data)

| Emission Sources | | $CH_4$ emissions (t/y) [1)] | Source sizes | Emission factors |
|---|---|---|---|---|
| High-pressure pipelines | New pipeline installation<br>Pipeline relocation | 180 | Total high-pressure pipeline<br>1799 km | 0.100<br>t-$CH_4$/km |
| Medium- and low-pressure pipelines and holders | Construction and demolition<br>Fugitive emissions<br>Burner and other inspections<br>Holder construction and overhauling | 93 | Total medium- and low-pressure pipeline<br>226,016 km | 0.411<br>kg-$CH_4$/km |
| Service pipes | Installing service pipes<br>Post-installation purging<br>Removal<br>Changing meters<br>Fugitive emissions, etc.<br>Rounds for opening valves and regular maintenance<br>Equipment repairs<br>(Especially high emissions when doing work at user sites (homes)) | 19 | User homes<br>27,298,000 | 0.696<br>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 *General Energy Statistics* (Agency for Natural Resources and Energy) as used as raw material for town gas.

Table 3-45 Liquefied natural gas used as material for town gas

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| LNG Consumption with Town Gas Production | PJ | 464 | 676 | 864 | 1,230 | 1,380 | 1,468 |
| Natural Gas Consumption with | PJ | 40 | 48 | 61 | 86 | 110 | 126 |

➢ ***Town gas supply networks***

Estimates use the high-pressure pipeline length, total medium- and low-pressure pipeline length, and number of users given in the *Gas Industry Yearbook* of the Agency for Natural Resources and Energy Gas Market Division.

Table 3-46 High-pressure pipeline length, total medium- and low-pressure pipeline length, and number of users

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| High-pressure pipeline length | km | 1,067 | 1,281 | 1,443 | 1,898 | 1,973 | 2,098 |
| total medium- and low-pressure | km | 180,239 | 197,474 | 214,312 | 230,430 | 233,741 | 236,729 |
| number of users | $10^3$ houses | 21,334 | 23,580 | 25,858 | 27,619 | 27,936 | 28,237 |

### c) *Uncertainties and Time-series Consistency*

● ***Uncertainties***

Although $CH_4$ emission factor of natural gas supplies is country-specific, the uncertainty of emission factor is the default value (25%) given in the *Good Practice Guidance (2000)* because the application of statistical treatment was considered to be unsuitable. The uncertainty of activity data was determined to be 8.7% by combing of the uncertainty of LNG and natural gas presented in *General Energy Statistics*. The uncertainties for emissions were estimated to be 26% for $CH_4$ emissions from natural gas supplies.

The uncertainties for emission factors of town gas supply network were the default values presented in *Good Practice Guidance (2000)*. For the uncertainty for activity data, the value preset by the Committee for Greenhouse Gas Emission Estimation Methods was applied. The uncertainties for emissions were estimated to be 27% for $CH_4$ emissions from town gas supply network. A summary of uncertainty assessment methods are provided in Annex 7.

● ***Time-series Consistency***

Emission factors have used consistent values from FY 1990 to FY 2007. Activity data have been calculated using annual data on LNG and natural gas consumption and town gas production from *General Energy Statistics* and data on the town gas supply network from the *Gas Industry Yearbook.* A consistent estimation method has been used from FY 1990 to FY 2007.

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

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

### e) *Source-specific Recalculations*

The emissions in FY 2005 were recalculated because of the revision of the values in FY 2005 reported in the *General Energy Statistics* and the *Gas Industry Yearbook* which were used as the basis for activity data in this category.

A new emission factor was created on the basis of FY2007 data provided by the Japan Gas Association, and recalculation was performed.

### f) *Source-specific Planned Improvements*

There are no major planned improvements in this source category.

#### 3.3.2.2.e. At industrial plants and power station / in residential and commercial sectors (1.B.2.b.v.)

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 town gas constituents, $CO_2$ emissions from this source are reported as "NA."

### 3.3.2.3. Venting and Flaring (1.B.2.c.)

Fugitive emissions of carbon dioxide and methane occur from venting during oil field development, crude oil transportation, refining processes, and product transportation in the petroleum industry and as well as during gas field development, natural gas production, transportation, and processing in natural gas industry.

Flaring during the above processes also emits carbon dioxide, methane, and nitrous oxide.

#### 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 $CH_4$ from venting in the petroleum industry.

***b） Methodological Issues***

●***Estimation Method***

Emissions from venting in the petroleum industry were calculated using the Tier 1 Method in accordance with the Decision Tree of *Good Practice Guidance (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 *Good Practice Guidance (2000)* were used for the emission factors of oilfield venting. (The median of the default values was used for methane).

Table 3-47 Emission factors of oilfield venting

| | | $CH_4$ 1) | $CO_2$ | $N_2O$ 2) |
|---|---|---|---|---|
| Conventional Oil | Venting valves [Gg/1000 $m^3$] | $1.38\times10^{-3}$ | $1.2\times10^{-5}$ | 0 |

Source: *GPG (2000)* Table 2.16
1) The default values are $6.2\times10^{-5}$ - $270\times10^{-5}$
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 the activity data of fugitive emissions from oilfield venting (see Table 3-34).

***c） Uncertainties and Time-series Consistency***

●***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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 $CO_2$ and $N_2O$. The uncertainty assessment methods are summarized in Annex 7.

●***Time-series Consistency***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using 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,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.)

Carbon dioxide and methane emissions from venting in the natural gas industry were considered only for the amount during transportation because. *Good Practice Guidance* (2000) provides emissions factors only for transportation. Intentional $CO_2$ emissions from natural gas pipelines are reported as “NA” because $CO_2$ emissions during 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 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 respectively 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***

Carbon dioxide, methane, and nitrous oxide emissions from flaring in the petroleum industry were calculated using the Tier 1 Method in accordance with the Decision Tree of *Good Practice Guidance*

*(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 *Good Practice Guidance* (2000) were used. It should be noted that the median values were used for methane emissions.

Table 3-48 Emission factors for flaring in the oil industry

| | | $CH_4$ 1) | $CO_2$ | $N_2O$ |
|---|---|---|---|---|
| Flaring (Conventional Oil) | $Gg/10^3\ m^3$ | $1.38\times10^{-4}$ | $6.7\times10^{-2}$ | $6.4\times10^{-7}$ |

Source: Good Practice Guidance (2000), Table 2.16

1) Default value: $0.05\times10^{-4}$ to $2.7\times10^{-4}$

● ***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 Ministry of Economy, Trade and Industry, were used. The production of condensate was excluded from the calculation (see Table 3-34).

### *c）Uncertainties and Time-series Consistency*

● ***Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using 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,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000).* The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.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***

Carbon dioxide, methane, and nitrous oxide emissions associated with flaring in the natural gas industry were calculated using the Tier 1 Method in accordance with the Decision Tree of *Good Practice Guidance (2000)*. Emissions were calculated by multiplying the amount of production of natural gas 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***

Table 3-49 Emission factors for flaring in the natural gas industry

| | | Units | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|
| Flaring in the natural gas industry | Gas production | $Gg/10^6m^3$ | $1.8\times10^{-3}$ | $1.1\times10^{-5}$ | $2.1\times10^{-8}$ |
| | Gas processing | $Gg/10^6m^3$ | $2.1\times10^{-3}$ | $1.3\times10^{-5}$ | $2.5\times10^{-8}$ |

Source: *Good Practice Guidance* (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 Ministry of Economy, Trade and Industry, were used (see Table 3-41).

#### c） *Uncertainties and Time-series Consistency*

**●*Uncertainties***

As the uncertainty of emission factors, default values given in the *Good Practice Guidance (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***

Emission factors have been used consistent values from FY 1990 to FY 2007. Activity data have been calculated using 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,* in a consistent estimation method from FY 1990 to FY 2007.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (2000)*. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. 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.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, 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 reactions in industrial processes produce atmospheric GHG emissions. This chapter describes the methodologies of estimating industrial process emissions shown in Table 4-1.

In 2007, total GHG emissions from the industrial processes sector amounted to approximately 78,802Gg-$CO_2$ equivalent, accounting for 5.4% of national total emissions (excluding LULUCF) in Japan. The emissions (excluding F-gases) from this sector had decreased by 22.9% compare to 1990. The emissions of halocarbons and $SF_6$ from this sector had decreased by 53.3% compare to 1995.

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

| 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 | NE | | ○ | | | |
| | 2.B.4. | Silicon carbide production | ○ | ○ | | | | |
| | | Calcium carbide production | ○ | NA | | | | |
| | 2.B.5. | Carbon black | | ○ | | | | |
| | | Ethylene | ○ | ○ | NA | | | |
| | | Dichloroethane | | ○ | | | | |
| | | Styrene | | ○ | | | | |
| | | Methanol | | NO | | | | |
| | | Coke | IE | ○ | NA | | | |
| 2.C. Metal production | 2.C.1. | Iron and steel | IE | NA | | | | |
| | | Pig iron | IE | NA | | | | |
| | | Sintered steel | IE | IE | | | | |
| | | Coke | IE | IE | | | | |
| | | Other (electric furnace) | ○ | ○ | | | | |
| | 2.C.2. | Ferroalloys production | IE | ○ | | | | |
| | 2.C.3. | Aluminum production | IE | NE | | | ○ | |
| | 2.C.4. | $SF_6$ used in Aluminum and Magnesium foundries: Aluminum | | | | | | NO |
| | | $SF_6$ used in Aluminum and Magnesium foundries: Magnesium | | | | | | ○ |
| | 2.C.5. | Other | NO | | | | | |
| 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 in production of HCFC-22 | | | | ○ | | |
| | 2.E.2. | Fugitive emissions | | | | ○ | ○ | ○ |

Table 4-1  Emission source categories in the industrial process sector (continue)

| 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 |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | | | Commercial Refrigeration | | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | | | Transport Refrigeration | | Manufacturing | | | | IE | NO | NO |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | | | Industrial Refrigeration | | Manufacturing | | | | IE | NO | NO |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | | | Stationary Air-Conditioning | | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | | | Mobile Air-Conditioning | | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock, Disposal | | | | IE | NO | NO |
| | 2.F.2. | Foam blowing | Hard Foam | Urethane Foam | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock | | | | ○ | NO | NO |
| | | | | | Disposal | | | | IE | NO | NO |
| | | | | Polyethylene Foam | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock, Disposal | | | | NO | NO | NO |
| | | | | Polystyrene Foam | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock | | | | ○ | 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 |
| | | | | | Stock | | | | ○ | NO | NO |
| | | | | | Disposal | | | | NO | NO | NO |
| | 2.F.4. | Aerosols/metered dose inhalers | Aerosols | | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock | | | | ○ | NO | NO |
| | | | | | Disposal | | | | IE | NO | NO |
| | | | Metered Dose Inhalers | | Manufacturing | | | | ○ | NO | NO |
| | | | | | Stock | | | | ○ | NO | NO |
| | | | | | Disposal | | | | IE | NO | NO |
| | 2.F.5. | Solvents | | | Manufacturing | | | | IE | IE | NO |
| | | | | | Stock | | | | IE | ○ | NO |
| | | | | | Disposal | | | | IE | IE | NO |
| | 2.F.6. | Other applications using ODS substitutes | | | | | | | NE | NA | NA |
| | 2.F.7. | Semiconductor manufacture | | | Manufacturing | | | | IE | IE | IE |
| | | | | | Stock | | | | ○ | ○ | ○ |
| | | | | | Disposal | | | | NA | NA | NA |
| | 2.F.8 | Electrical equipment | | | Manufacturing | | | | | | ○ |
| | | | | | Stock | | | | | | ○ |
| | | | | | Disposal | | | | | | IE |
| | 2.F.9 | Other (for research, healthcare, etc.) | | | | | | | NA | NE | IE |

## 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 2007, emissions from Mineral Products were 50,219 Gg-$CO_2$, and represented 3.7% of total GHG emissions. The emissions had decreased by 12.5% compared to 1990.

### 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.

<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 an 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 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 so 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 total CaO content of clinker. Japan assumes 1.00 for the cement kiln dust (CKD) correction coefficient because it is deemed likely that all CKD is recovered and used again as an input.

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.

*<u>Emission factors of $CO_2$ emissions from cement production</u>*

= [(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 seven types of waste and other materials were chosen for this calculation: coal ash (incineration residue), blast furnace slag (water granulated), blast furnace slag (slow-cooled), steelmaking slag, nonferrous slag, coal ash (from dust collectors), and particulates/dust (these waste account for over 90% of the CaO from waste and other materials). Waste amounts (emission-based) and the content percentages 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 volume 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 4-2 Emission factors of $CO_2$ from cement production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| CaO content in clinker | % | 65.9 | 65.9 | 66.0 | 65.9 | 65.9 | 65.9 |
| Waste Origin CaO content in clinker | % | 2.5 | 2.5 | 2.9 | 1.8 | 1.8 | 1.9 |
| CaO content in clinker except waste origin CaO | % | 63.4 | 63.4 | 63.1 | 64.0 | 64.1 | 64.0 |
| $CO_2$/CaO | | 0.785 | 0.785 | 0.785 | 0.785 | 0.785 | 0.785 |
| EF | t/$CO_2$ | 0.498 | 0.498 | 0.495 | 0.502 | 0.503 | 0.502 |

● ***Activity Data***

Cement Association provides the data for 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) and limestone consumption (Ministry of Economy, Trade and Industry, Yearbook of Ceramics and Building Materials Statistics).

Limestone consumption data for FY1993 to FY2003 given in the Yearbook of Ceramics and Building Materials Statistics include limestone consumption for cement hardening agents, which is not included in statistics for 1992 and previous years. For this reason, the Ministry of Economy, Trade and Industry has estimated the data for 1990–1992 limestone consumption including cement hardening agent.

To make the corrections, a connection coefficient (0.99) was used to calculate FY1990–FY1992 cement production including hardening agent raw material (cement production ÷ 0.99), and the result was multiplied by the ratio of limestone consumption to cement production (limestone consumption ÷ cement production) to calculate limestone consumption.

Table 4-3 Clinker production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Consumption of Limestone | kt (dry) | 89,366 | 97,311 | 81,376 | - | - | - |
| Clinker Production (actual performance) | kt | | | 69,528 | 63,003 | 62,404 | 59,885 |
| Clinker Production / Consumption of Limestone | | 0.853 | 0.853 | | | | |
| Clinker Production afrer correction | kt | 76,253 | 83,032 | 69,528 | 63,003 | 62,404 | 59,885 |

* Clinker Production / Consumption of Limestone 1990-1999 is the average value 2000-2003

## c) Uncertainties and Time-series Consistency

● ***Uncertainty***

For the uncertainty of $CO_2$ emission factor from cement production, the value given in the *GPG (2000)* was applied. 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 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 produced by the Cement Association. For years after 2000, 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 limestone ($CaCO_3$) and other materials used as raw material to produce quicklime.

| $CO_2$ generation mechanism of quicklime production process |
|---|
| $CaCO_3 \rightarrow CaO + CO_2$ |
| $MgCO_3 \rightarrow MgO + CO_2$ |

### *b) Methodological Issues*

● ***Estimation Method***

$CO_2$ emissions are calculated according to the Tier 1 method in *GPG (2000)* in which amounts of high calcium quicklime and dolomitic quicklime produced are multiplied by the country-specific emission factors.

| *$CO_2$ emissions (t-$CO_2$) generated by use of raw materials in quicklime production* |
|---|
| = raw material-specific emission factor (t-$CO_2$/t-product) × amount of quicklime and dolomitic quicklime |

● ***Emission Factors***

Emission factors (EF) specific to Japan were determined on the basis of emission factors per unit raw material ($EF_{raw}$) (limestone and dolomite) provided by the Japan Lime Association (Table 4-4).

Emission factors per unit raw material ($EF_{raw}$) were calculated by finding the $CO_2$ emissions per unit raw material estimated from the amounts of carbon and other substances in raw material constituents according to producing district, and in quicklime products, and then finding the weighted averages using production amounts of each district. The raw material for high-calcium lime is limestone, while that for calcined dolomite is dolomite.

Table 4-4 Emission factors for lime production

| | unit | high-calcium lime | dolomitic lime |
|---|---|---|---|
| Emission factors per unit raw material ($EF_{raw}$)* | t-$CO_2$/t-raw material | 0.428 | 0.449 |
| Lime products per unit raw material | t-product/t-raw material | 0.572 | 0.551 |
| Emission factors (EF) utilized for estimation | t-CO2/t-product | 0.748 | 0.815 |

* : the data provided by the Japan Lime Association

Emission Factors (EF) were set by the following equation.

*Emission Factors* EF [t-$CO_2$/t-product]

= $EF_{raw}$ [t-$CO_2$/t-raw material] / lime product per unit raw material [t-production/t-raw material]

= $EF_{raw}$ [t-$CO_2$/t-raw material] / ( 1 - $EF_{raw}$ [t-$CO_2$/t-raw material])

The emission factor of lime production is the same for all years because annual change is thought to be small.

● ***Activity Data***

The volume of quicklime produced according to the Ministry of Economy, Trade and Industry's Yearbook of Chemical Industries Statistics was used as activity data for $CO_2$ emissions associated with the manufacture of quicklime (high calcium lime). The volume of dolomitic quicklime produced according to the Japan Lime Association's Demand Outlook by Application was used as activity data for dolomitic quicklime.

Table 4-5 Production values of quicklime and dolomitic quicklime

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Quicklime Production | kt | 9,030 | 7,813 | 8,038 | 8,868 | 9,146 | 9,483 |
| Dolomitic lime Production | kt | 696 | 572 | 499 | 665 | 720 | 866 |

### c) Uncertainties and Time-series Consistency

● ***Uncertainty***

The uncertainty for quicklime and dolomitic lime 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, the standard value given by the Committee for the Greenhouse Gas Emission Estimation Methods was used (5% for quicklime, 10% for dolomitic lime). As a result, the uncertainty of quicklime was estimated to be 16% and dolomitic lime was estimated to be 18%. The uncertainty assessment methods are summarized in Annex 7.

- ***Time-series consistency***

Quicklime and dolomitic lime production statistics have been provided by Yearbook of Chemical Industries Statistics (Ministry of Economy, Trade and Industry) and Japan Lime Association's Demand Outlook by Application, respectively, for all years. The emission factors are constant for all years. 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*

Emissions for all years have been recalculated using the country specific emission factors determined this year.

### *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 use of limestone and dolomite releases $CO_2$ derived from $CaCO_3$ and $MgCO_3$.

<u>$CO_2$ generating mechanism of limestone and dolomite use</u>

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

### *b) Methodological Issues*

- ***Estimation Method***

The volumes of limestone and dolomite used in iron and steel production and as raw materials in soda-lime glass are multiplied by the emission factors to calculate emissions.

- ***Emission Factors***

➢ ***Limestone***

The emission factors of limestone used in manufacturing steel and soda-lime glass are 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]).

**$CaCO_3 \rightarrow CaO + CO_2$**
**$MgCO_3 \rightarrow MgO + CO_2$**

- 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 %

(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[c]
- 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
  = (55.4% × 100.0869) / 56.0774 × 100 = 98.88%
- $MgCO_3$ content = proportion of MgO extractable from limestone × molecular weight of $MgCO_3$ / molecular weight of MgO
  = 0.5% × 84.3139 / 40.3044 = 1.05%

○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)
＝44.0095 / 100.0869*0.9888+44.0095/84.3139*0.0105
＝0.4348＋0.0055＝0.4402 [t-$CO_2$/t]
＝440 [kg-$CO_2$/t]

Sources)
a. IUPAC "Atomic Weights of the Elements 1999"
(http://www.chem.qmul.ac.uk/iupac/AtWt/AtWt9.html)

### ➢ *Dolomite*

The emission factor of dolomite 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]).

**$CaCO_3 \rightarrow CaO + CO_2$**
**$MgCO_3 \rightarrow MgO + CO_2$**
- 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%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
  = 34.5% × 100.0869 / 56.0774
  = 61.53%
- $MgCO_3$ content= proportion of MgO extractable from dolomite × molecular weight of $MgCO_3$ / molecular weight of MgO
  = 18.3% × 84.3142 / 40.3044
  = 38.39%

○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
＝ 44.0098 / 100.0869×0.6153＋44.0098 / 84.3142×0.3839
＝ 0.2706＋0.2004
＝ 0.4709 [t-$CO_2$/t]
＝ 471[kg-$CO_2$/t]

● ***Activity Data***

The activity of limestone and dolomite sold for use in steel refining and soda glass given in the Ministry of Economy, Trade and Industry's Yearbook of Minerals and Nonferrous Metals Statistics and Yearbook of Mineral Resources and Petroleum Products Statistics are used as activity data for $CO_2$ emissions from limestone and dolomite use.

Table 4-6 Amounts of limestone and dolomite sold for use in steel refining and soda glass

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Limestone (steel/ smelting) | kt | 22,375 | 22,371 | 22,902 | 23,971 | 24,057 | 25,166 |
| Limestone (soda glass) | kt | 1,846 | 1,946 | 1,722 | 997 | 1,067 | 1,291 |
| Dolomite (steel/ smelting) | kt | 1,619 | 771 | 438 | 396 | 442 | 624 |
| Dolomite (soda glass) | kt | 228 | 197 | 177 | 154 | 143 | 146 |

***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 standard value given by the Committee for the Greenhouse Gas Emission Estimation Methods was used to estimate uncertainty of activity data. 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***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. Therefore, $CO_2$ emission from limestone and dolomite 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***

When the mineral products such as lime products and soda ash are produced from the limestone counted in "soda glass" and "steel and smelting", there is a possibility of a double count in the amount of emissions. Therefore, it is necessary to investigate the post-marketing utilization and consumption of the limestone closely.

### 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 according to the *Revised 1996 IPCC Guidelines* by multiplying the amount of soda ash consumed by the default emission factor.

● ***Emission Factors***

Because Japan does not have its own measured data or emission factor, the default value (0.415 t-$CO_2$/t-$Na_2CO_3$) in the *Revised 1996 IPCC Guidelines* (vol. 3 p. 2.13) is used.

● ***Activity Data***

Activity data are the total of (1) shipping totals from Japan Soda Industry Association data, (2) imports and exports of soda ash from trade statistics, and (3) imports and exports of other sodium sesquicarbonate from trade statistics.

Table 4-7 Soda ash use

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Soda Ash Shipping | kt | 1,098 | 977 | 634 | 427 | 440 | 430 |
| Soda Ash Imported | kt | 0.00 | 8.25 | 53.12 | 131.13 | 103.66 | 120.30 |
| Other Disodium Carbonate Imported | kt | 308 | 299 | 360 | 303 | 251 | 269 |

#### c) *Uncertainties and Time-series Consistency*

● ***Uncertainty***

For the uncertainty of the emission factor from soda ash use, the limestone and dolomite use value of was applied as it is a similar source category as soda ash. For the uncertainty of activity data, 6.3% uncertainty was estimated as a result of combining the uncertainty of lime production. As a result, 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***

For activity data, the same sources are used throughout the time series. The emission factor is constant throughout the time series. 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***

There have been no source-specific recalculations.

***f） Source-specific Planned Improvements***

The default emission factor is assumed that the purity of the soda ash is 100%. However, soda ash used in Japan is not 100% so it is necessary to set the country-specific emission factor.

### 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 carbon dioxide is not emitted from the manufacture 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 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 2007, emissions from Chemical Industry were 4,276 Gg-$CO_2$, and represented 0.3% of GHG of the Japan’s total GHG emissions. The emissions had decreased by 67.4% compared to 1990.

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

***a） Source/Sink Category Description***

***1） $CO_2$***

$CO_2$ is emitted when hydrocarbon feedstock in ammonia production is broken down to make $H_2$ feedstock.

<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 any sufficient examples enough to enable the establishment of an emission factor, it is not currently possible to calculate emission levels. 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 the ammonia production is not theoretically conceivable, 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 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 4-8. 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 4-8 Emission factors and calorific values of feedstocks used when producing ammonia

| Feedstock | Emission Factors (Gg-C/TJ) | (sources) | Calorific value | | (Units) |
|---|---|---|---|---|---|
| | | | 1990 | 2005 | |
| Naphtha | 18.2 | 1992 carbon emission factor | 33.5 | 33.6 | MJ/l |
| Liquefied petroleum gas (LPG) | 16.3 | 1992 carbon emission factor | 50.2 | 50.8 | MJ/kg |
| Petroleum-derived hydrocarbon gases (petrochemical offgases) | 14.2 | 1992 carbon emission factor | 39.3 | 44.9 | MJ/m$^3$ |
| Natural gas | 13.9 | Kainou (2003) | 41.0 | 43.5 | MJ/m$^3$ |
| Coal (thermal coal, imports) | 24.7 | 1992 carbon emission factor | 26.0 | 25.7 | MJ/kg |
| Petroleum coke | 25.4 | 1992 carbon emission factor | 35.6 | 29.9 | MJ/kg |
| Liquefied natural gas (LNG) | 13.5 | 1992 carbon emission factor | 54.4 | 54.6 | MJ/kg |
| Coke oven gas (COG) | 11.0 | Kainou (2003) | 20.1 | 21.1 | MJ/m$^3$ |

● ***Activity Data***

The fixed units (including weight and volume) for the fuel types in the table 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 4-9 Amount of feedstocks used for ammonia production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Naphtha | kl | 189,714 | 477,539 | 406,958 | 92,453 | 80,755 | 77,214 |
| LPG | t | 226,593 | 45,932 | 5,991 | 0 | 0 | 0 |
| Off gas | $10^3m^3$ | C | 230,972 | 240,200 | 147,502 | 149,927 | 144,196 |
| Natural Gas | $10^3m^3$ | C | 100,468 | 86,873 | 77,299 | 67,225 | 50,986 |
| Coal | t | C | 209,839 | 726 | 1,239 | 1,066 | 763 |
| Oil Coke | t | C | 273,125 | 420,862 | 353,983 | 365,068 | 407,213 |
| LNG | t | C | 46,501 | 23,395 | 165,606 | 180,923 | 180,161 |
| COG | $10^3m^3$ | C | 35,860 | 55,333 | 0 | 0 | 0 |

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. The emission factor is constant 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*

Activity data for 2005 was updated to reflect the newly published 2005FY data in the Yearbook of the Current Survey of Energy Consumption (2006). Calendar year data was used in the previous submission.

### *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 by nitric acid ($HNO_3$) production.

<u>$N_2O$ generating mechanism of nitric acid production generates $N_2O$</u>

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$
$$2NO + H_2O \rightarrow 2NO_2$$
$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO \quad (\rightarrow N_2O)$$

### b） Methodological Issues

#### ● Estimation Method

$N_2O$ emissions were estimated by multiplying the nitric acid production volume by an emission factor, based on the method given in *GPG (2000)* (page 3.31, Equation 3.9). Because emissions data for individual factories is confidential information, nitric acid production volume and emission factors were set for Japan's total production. Due to the current lack of data on the amount of $N_2O$ destroyed, the equation has no term for destruction.

*$N_2O$ emissions (kg-$N_2O$) from nitric acid production*
= emission factor [kg-$N_2O$/t] × nitric acid production volume [t]

#### ● Emission Factors

Because data for individual factories are confidential, emission factors were set by using each factory's nitric acid production volume to find the weighted average of each factory's emission factor, based on measurements made at the 10 nitric acid producing factories in Japan. These emission factors take $N_2O$ recovery and destruction into account.

Table 4-10 $N_2O$ emission factors for nitric acid production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| EF for Nitric Acid Production | kg-$N_2O$/t | 3.50 | 3.51 | 3.92 | 4.18 | 3.34 | 3.22 |

#### ● Activity Data

Production volumes of nitric acid (converted at 98%) are directly provided by the Ministry of Economy, Trade and Industry.

Table 4-11 Amount of Nitric acid production

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Nitric Acid Production | t | 705,600 | 701,460 | 655,645 | 602,348 | 682,680 | 590,332 |

### c） Uncertainties and Time-series Consistency

#### ● Uncertainty

The uncertainty of the emission factor was estimated using 95% confidence interval of 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 estimated using the activity data and emission factors provided by Ministry of Economy, Trade and Industry in a consistent manner.

### 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*

There may be some production by manufacturing plants of nitric acid, which is not included in the activity data.

## 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 volume, and adipic acid production volume of the relevant operating sites, in accordance with the *GPG (2000)* decision tree (Page 3.32, Fig. 3.4).

*$N_2O$ emissions from adipic acid production*
= [$N_2O$ generation rate × (1–$N_2O$ generation rate × decomposition unit operating rate)]
× adipic acid production rate

#### ● *Emission Factors*

Values calculated using the above equation has been used as the 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 hours operated is conducted annually for $N_2O$ decomposition units and adipic acid production plants. The operating rate is based on this survey.

*Calculation of operating ratio of decomposition unit*

Operating ratio of decomposition unit (%)
= Number of hours worked of decomposition unit
/ Number of hours worked of adipic acid production plants × 100 (%)

Number of hours of decomposition unit in operation:
Hours starting from the beginning of feeding the entire volume of $N_2O$ gases till the end of feeding

Number of hours of adipic acid production plants in operation:
Hours starting from the beginning of feeding materials till the end of feeding

● ***Activity Data***

The activity data for nitrous oxide emissions associated with the manufacture of adipic acid is the amount of adipic acid produced which is 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 was installed in adipic acid production plants in May 1999, the emissions since then have decreased dramatically. There was a temporary growth of 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 generation rate, emission factor, and the operating rate. As a result, the uncertainty of the emission factor was estimated as 9%. 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 are provided by producer of adipic acid are used to estimate emissions throughout the time series in a consistent manner.

***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 (2.B.4.-)

***a） Source/Sink Category Description***

***1） $CO_2$***

$CO_2$ is emitted by the use of petroleum coke as a raw material in the production of silicon carbide.

<u>$CO_2$ generating mechanism of the silicon carbide production process</u>

$$SIO_2 + 3C \rightarrow SiC + 2CO \rightarrow 2CO_2$$

### *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 measured 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, which is 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 from electric arc furnaces (12.8 kg-$CH_4$/TJ) was determined by using the formula for calculating fuel combustion and actual data from Japanese measurement surveys of $CH_4$ concentrations in gas ducts, concentrations of $O_2$ and theoretical flue gas amounts (dry), theoretical air demand, and high calorific values. See Chapter 3 3.2.1 Stationary Combustion (1.A.1., 1.A.2., 1.A.4.: $CH_4$ and $N_2O$)

● ***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 4-12 Energy consumption from electric arc furnaces (for carbide)

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Furnaces (for Carbide) | TJ | 1,576 | 4,277 | 2,454 | 2,454 | 2,454 | 2,454 |

***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 and activity data were estimated as 163% and 5%, respectively, as estimated in Chapter 3. The uncertainty for emissions is estimated as 163%. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

For $CO_2$ and $CH_4$ activity data, the same sources are used throughout the time series. 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***

There have been no source-specific recalculations.

***f) Source-specific Planned Improvements***

The use of fuel consumption data in the MAP Survey for FY 2002 onward is prohibited for any purposes other than the original one specified for the Map Survey, while that is not the case with the data in the MAP Survey for FY 1999 and earlier years. Therefore, for emission estimation after FY 2000, the ratio of each furnace type associated with consumption of each fuel type in each sector estimated based on the data in FY 1999 was used. It is currently under consideration by the government whether an arrangement should be made to enable use of the data in the MAP Survey for FY 2002 onward.

### 4.3.4.2. Calcium Carbide (2.B.4.-)

***a) Source/Sink Category Description***

***1) $CO_2$***

$CO_2$ is generated in the process of making the quicklime used in calcium carbide production. $CO_2$ is also emitted by CO combustion when making calcium carbide. Further, calcium carbide is made to react with water, producing calcium hydroxide (slaked lime) and acetylene, and $CO_2$ is generated when the acetylene is used.

CO$_2$ generator mechanism of the calcium carbide production process
(Production)
$$CaCO_3 \rightarrow CaO + CO_2$$
$$CaO + 3C \rightarrow CaC_2 + CO\ (\rightarrow CO_2)$$
(Use)
$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2 \rightarrow 2CO_2$$

### 2) $CH_4$

Byproduct gases (mainly CO) generated in carbide reactions 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 default emission factor, based on the *Revised 1996 IPCC Guidelines*.

*$CO_2$ emissions in conjunction with calcium carbide production and consumption*
= ∑(emission factors of $CO_2$ from limestone, from reducing agent, and use)
× calcium carbide production volume

### ● Emission Factors

Because Japan does not have its own measured data or emission factors, this inventory uses the default values given in the *Revised 1996 IPCC Guidelines* for the emission factors of $CO_2$ from limestone, from reducing agent, and use.

Table 4-13 Emission factors of $CO_2$ generated by calcium carbide production and consumption

| Units | From limestone in production | From reducing agent in production | From use |
|---|---|---|---|
| t-$CO_2$/t | 0.76 | 1.09 | 1.1 |

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

### ● Activity Data

Calcium carbide production data provided by the Carbide Industry Association are used as the calcium carbide production volume. 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 throughout the time series. Therefore, $CO_2$ emission from calcium carbide 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***

The default $CO_2$ emission factor used for this source may not reflect Japan's national circumstances. It is necessary to collect the data for the setting of the country-specific emission factor.

### 4.3.5. Other (2.B.5.)

#### 4.3.5.1. Carbon Black (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 volume by Japan's emission factor, in accordance with the *Revised 1996 IPCC Guidelines*.

- ***Emission Factors***

Five major companies, providing 96% of domestic production, recover methane 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 methane during routine inspections and the boiler inspection carried out by the five major domestic producers, deriving from weighted averages and using production volumes of carbon black. The emission factor is 0.35 [kg-$CH_4$/t].

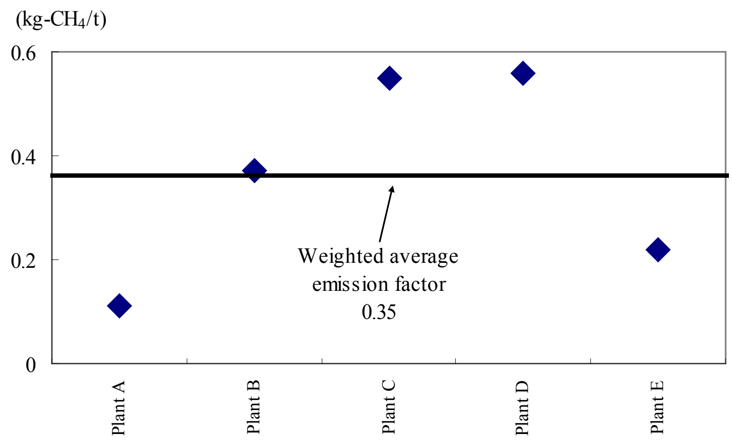


Figure 4-1 $CH_4$ Emission factor for carbon black production

Source: Data provided by the Carbon Black Association

Table 4-14 Methane emissions and carbon black production by five main domestic producers

| | Carbon black production [t/year] | Methane 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 (1998 actual results)

● ***Activity Data***

Carbon black production volumes given in the Yearbook of Chemical Industries Statistics compiled by the Ministry of Economy, Trade and Industry were used for activity data for methane emissions associated with the manufacture of carbon black.

Table 4-15 Carbon black production volume

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Carbon Black Production | t | 792,722 | 758,536 | 771,875 | 805,461 | 832,470 | 840,634 |

### *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 sources 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 with $CH_4$ from furnaces in the Energy sector should be investigated.

#### 4.3.5.2. Ethylene (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 stream cracking in the ethylene production process.

*2) $N_2O$*

There is almost no nitrogen in naphtha, the raw material in ethylene production, 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 in principle 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 a Japan-specific emission factor, in accordance with the *Revised 1996 IPCC Guidelines*.

● ***Emission Factors***

➢ ***$CO_2$***

Emission factors for a normal operation and an unsteady operation at operating sites in Japan were established using actual measurement data recorded in FY2000. The emission factor was set, assuming that all carbon dioxide separated in the naphtha-cracking and refinement sector is emitted, which was a pre-condition in establishing the emission factor. This emission factor is confidential.

➢ ***$CH_4$***

Estimates of volume of exhaust gas from flare stacks at a normal operation and an unsteady operation at operating sites in Japan (assuming that 98% of the volume that enters is combusted), and measured volume of exhaust gas from naphtha cracking furnace and furnaces heated by re-cycled gas, were divided by the production volume to calculate emission factors for each company. The weighted average of production from each company was then applied to establish the emission factor. The emission factor is 0.015 [kg-$CH_4$/t].

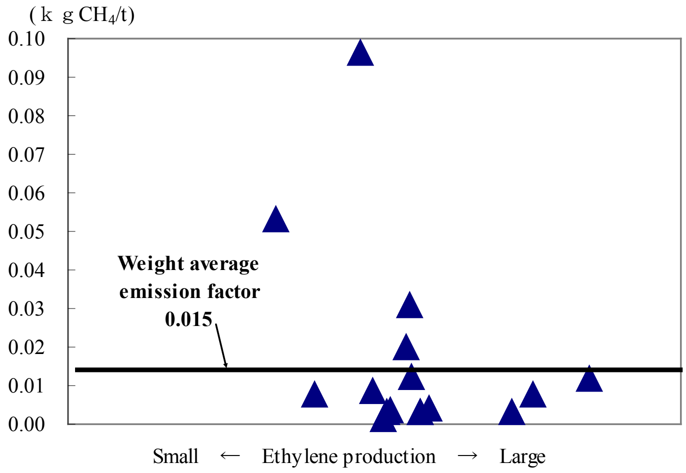


Figure 4-2 Emission factor for methane from manufacturing ethylene

Source: Data provided by the Japan Petrochemical Industry Association

● ***Activity Data***

Ethylene production volumes from the Yearbook of Chemical Industries Statistics compiled by the Ministry of Economy, Trade and Industry were used as activity data for emissions of methane and carbon dioxide from ethylene production.

Table 4-16 Ethylene production volume

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Ethylene Production | kt | 5,966 | 6,951 | 7,566 | 7,549 | 7,661 | 7,559 |

### *c) Uncertainties and Time-series Consistency*

● ***Uncertainty***

The uncertainty for both $CO_2$ and $CH_4$ emission factors for ethylene were calculated by finding the 95% confidence interval of emission factors. The estimated uncertainty was 77.2%. 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 for both $CO_2$ and $CH_4$ were estimated at 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*

The emission factor applied to the estimation was set based on the data in fiscal year 2000. When it is recognized that the emission factor doesn't suit the realities of our country, the emission factor will be revised.

### 4.3.5.3. 1,2-Dichloroethane (2.B.5.-)

#### *a） Source/Sink Category Description*

1,2-dichloroethane is made 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 volume by a Japan-specific emission factor, in accordance with the *Revised 1996 IPCC Guidelines*.

● ***Emission Factors***

The concentration of methane 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 weighted averages were calculated to establish the emission factor. The emission factor is 0.0050 [kg-$CH_4$/t].

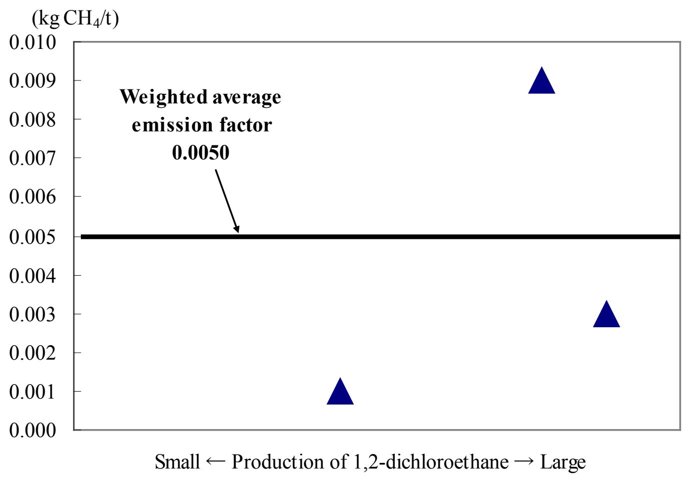


Figure 4-3 Methane emission factors for 1,2-dichloroethane production

Source: Data provided by the Vinyl Environmental Council

● ***Activity Data***

Dichloroethane production volumes from the Yearbook of Chemical Industries Statistics compiled by the Ministry of Economy, Trade and Industry were used as activity data for methane emissions from 1,2-dichloroethane production.

Table 4-17 Ethylene dichloride (1,2-dichloroethane) production volume

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Ethylene dichloride Productio | kt | 2,683 | 3,014 | 3,346 | 3,639 | 3,511 | 3,517 |

### *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 using 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, $CO_2$ and $CH_4$ 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 impruvements are planned.

## 4.3.5.4. Styrene (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 volume by a Japan-specific emission factor, based on the method given in the *Revised 1996 IPCC Guidelines*.

**● *Emission Factors***

Estimates of volume of exhaust gas from flare stacks at a normal operation and an unsteady operation at operating sites in Japan (assuming that 98% of the volume that enters is combusted), and measured volume of waste gas from heating furnaces, were divided by the production volume to calculate emission factors for each company. The weighted average of production from each company was then applied to establish the emission factor. The emission factor is 0.031 [kg-$CO_2$/t].

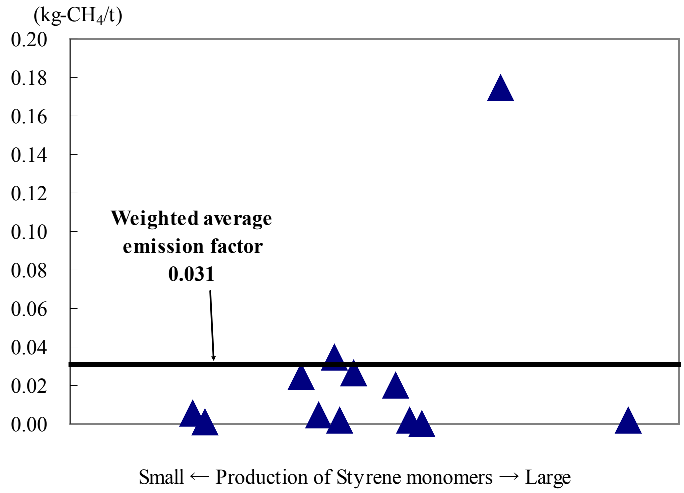


Figure 4-4    Methane emission factors for styrene production

Source: Data provided by the Japan Petrochemical Industry Association

- ***Activity Data***

Styrene monomer production volumes from the Yearbook of Chemical Industries Statistics compiled by the Ministry of Economy, Trade and Industry were used as activity data for methane emissions from styrene production.

Table 4-18    Styrene (monomer) production volume

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Styrene Production | kt | 2,227 | 2,952 | 3,020 | 3,375 | 3,373 | 3,417 |

### c) Uncertainties and Time-series Consistency

- ***Uncertainty***

The uncertainty for the $CH_4$ emission factor for styrene production was estimated by finding the 95% confidence interval of emission factors. The estimated uncertainty was 113.2%. 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 for 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*

The country specific $CH_4$ emission factor has been estimated from measurements of emissions from flare stacks/styrene cracking furnaces (naphtha cracking furnace)/ regeneration gas furnaces which may also include energy emissions. If necessary, the energy emissions and process emissions should be split.

## 4.3.5.5. Methanol (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 was also no production of refined methanol. Because the methanol refining process merely dewaters the synthesized methanol, in principle no $CH_4$ is generated.

Accordingly, from 1990 to 1995, emissions are reported using the production volumes in industry organization statistics. For 1996 and thereafter, the report is "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 volumes of methanol (on calendar year basis) given in Methanol Supply and Demand published by the Methanol and Formalin Association were used as activity data for methane emissions from methanol production.

Table 4-19 Methanol production volume

| Item | Unit | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|
| Methanol Production | t | 83,851 | 76,772 | 23,043 | 45,426 | 40,662 | 75,498 |

### *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 (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 reducing atmosphere in a coke oven is normally at least 1,000°C.

***b） Methodological Issues***

- ***Estimation Method***

$CH_4$ emissions from coke production were calculated by multiplying coke production volume by a Japan-specific emission factor, based on the method given in the *Revised 1996 IPCC Guidelines*.

- ***Emission Factors***

Methane emissions from coke production come from two sources: methane in combustion exhaust gas that leaks between the carbonization chamber and the combustion chamber, and methane emitted from the coking furnace lid, the desulfurization tower, or the desulfurization recycling tower, in the carbonization process.

➢ ***Combustion exhaust gas***

The production volume of coke was used in conjunction with the concentration of methane in the exhaust gas from coking furnaces operated by five companies at seven operating sites (surveyed by the Japan Iron and Steel Federation) to derive a weighted average, which was established as the emission factor. The emission factor is 0.089 [kg-$CH_4$/t].

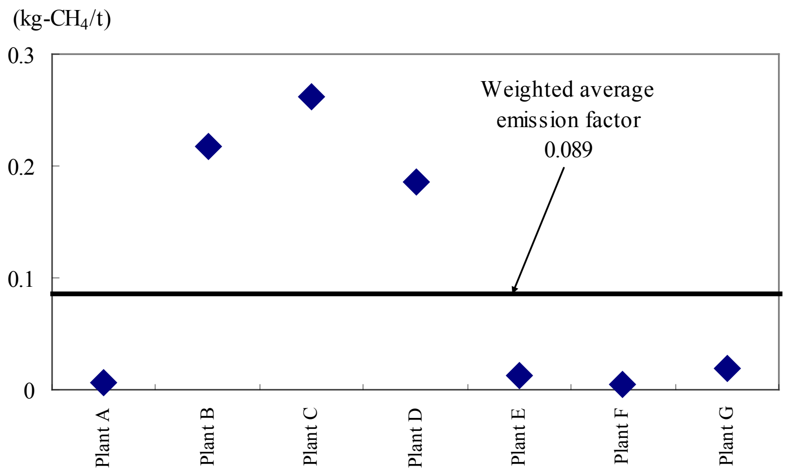


Figure 4-5 Emission factors for methane in combustion exhaust gas from coking furnaces

Source: Data provided by the Japan Iron and Steel Federation

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

The Japan Iron and Steel Federation has had a voluntary plan in place since fiscal 1997 to manage noxious atmospheric pollutants, and methane 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 volume of production of coke.

Table 4-20 Emission factor of methane from coking furnace lids, desulfurization towers, and desulfurization recycling towers

| Fiscal year | $CH_4$ emission factors [kg-$CH_4$/t] | Notes |
|---|---|---|
| 1990-1996 | 0.238 | Emission factor change is assumed to be small. 1995 data is used for year with no data. |
| 1997-1999 | 0.180 | It is assumed that values for 1998 and 1999 are about the same as those of 1997. |
| 2000 | 0.101 | Actual results. |
| 2005 | 0.043 | Actual results. |
| 2006 | 0.039 | Actual results. |
| 2007 | 0.040 | Actual results. |

Source: Japan Iron and Steel Federation data

➢ ***Methane 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 volume given in the Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke and the Yearbook of Mineral Resources and Petroleum Products Statistics compiled by the Ministry of

Economy, Industry and Trade.

Table 4-21 Coke production volume

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Coke Production | kt | 47,338 | 42,279 | 38,511 | 38,009 | 38,720 | 38,867 |

- ***Completeness***

The SBDT[1] (Table 2(I).A-Gs2) in the CRF requires emissions of carbon dioxide and methane 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 $CO_2$, $CH_4$, PFCs and $SF_6$ emissions from the manufacturing processes of metal productions.

This section includes GHG emissions from three sources: Iron and Steel Production (2.C.2), Ferroalloys Production (2.C.2.) Aluminium Production (2.C.3.) and $SF_6$ Used in Aluminium and Magnesium Foundries (2.C.4.).

[1] SBDT: Sectoral Background Data Table

In 2007, emissions from Metal Production were 1,240 Gg-$CO_2$, and represented 0.1 % of GHG of the Japan's total GHG emissions. The total emissions of $CO_2$ and $CH_4$ from this category had decreased by 38.9 % compared to 1990. The total of halocarbons and $SF_6$ had increased by 434.2 % compared to 1995.

### 4.4.1. Iron and Steel Production (2.C.1.)

#### 4.4.1.1. Steel (2.C.1.-)

***1） $CO_2$***

Coke oxidizes when it is used as a reduction agent in the steel production, and carbon dioxide is generated. The volume of coke used has been included under consumption of fuel in Fuel Combustion Sector (1.A.), and the carbon dioxide generated through the oxidization of coke used as a reducing agent has already been calculated under Fuel Combustion Sector (1.A.), too. Therefore, it has been reported as "IE".

#### 4.4.1.2. Pig Iron (2.C.1.-)

***1） $CO_2$***

Carbon dioxide 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 Fuel Combustion Sector (1.A.), and the carbon dioxide generated through the oxidization of coke used as a reducing agent has already been calculated under Fuel Combustion Sector (1.A.), too. Therefore, it has been reported as "IE".

***2） $CH_4$***

It is not theoretically possible that methane will be generated in association with the pig iron production, and it has been confirmed that methane is not emitted from actual measurements. Therefore, emissions have been reported as "NA".

#### 4.4.1.3. Sinter (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 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 (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 methane were calculated at 4.2.5.6. 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.

***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 atmosphere as $CO_2$. The carbon include in electric furnaces gas given in the General Energy Statistics are subtracted from the $CO_2$ emission in this source since this emission 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 4-22 $CO_2$ emission from carbon electrodes of furnaces

| | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| #A Import | t | 12,341 | 18,463 | 11,363 | 15,075 | 13,893 | 15,035 |
| #B Domestic production | t | 211,933 | 186,143 | 184,728 | 216,061 | 221,112 | 229,734 |
| #C Export | t | 87,108 | 92,812 | 107,998 | 138,409 | 149,330 | 150,491 |
| #D Electric furnaces gas | t | 39,983 | 14,300 | 20,293 | 26,700 | 37,217 | 36,415 |
| Domestic consumptions (#A+#B-#C-#D) | t | 97,184 | 97,493 | 67,800 | 66,028 | 48,458 | 57,864 |
| $CO_2$ emissions | Gg-$CO_2$ | 356 | 357 | 248 | 242 | 178 | 212 |

**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 from electric arc furnaces (12.8 kg-$CH_4$/TJ) was determined by using the Japanese measurement surveys. (See Chapter 3 3.2.1 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 4-23 Energy consumption from electric arc furnaces

| Consumption | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Furnaces | TJ | 57,564 | 55,986 | 52,457 | 52,747 | 55,051 | 55,687 |

### *c） Uncertainties and Time-series Consistency*

#### *1） $CO_2$*

- ***Uncertainty***

Because all $CO_2$ from electric arc furnaces are assumed to escape in the atmosphere, no emission factor has been set. Therefore, the uncertainty for activity data is also the uncertainty for emissions. 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 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*

There have been no source-specific recalculations.

### *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 carbon dioxide 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 Fuel Combustion Sector (1.A.), and carbon dioxide generated as a consequence of the oxidization of coke used as a reduction agent has already been calculated under 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 to the atmosphere as carbon dioxide. 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. Methane 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***

Methane emissions from ferroalloy production 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.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 4-24 Energy consumption from ferroalloy production

| Consumption | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Furnaces (for Ferroalloy) | TJ | 14,456 | 10,699 | 10,181 | 10,072 | 8,783 | 8,676 |

### *c) Uncertainties and Time-series Consistency*

- ***Uncertainty***

The uncertainty for 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*

There have been no source-specific recalculations.

#### *f) Source-specific Planned Improvements*

No improvements are planned.

### 4.4.3. Aluminium Production (2.C.3.)

#### *a) Source/Sink Category Description*

#### *1) $CO_2$*

Aluminum refining is conducted in Japan. Carbon dioxide 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 Fuel Combustion Sector (1.A.), and the carbon dioxide that is generated by 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) $CH_4$*

Aluminum refining is conducted in Japan. There is a small amount of hydrogen in the pitch that act as a raw material for the anode paste used in aluminum smelting. Theoretically, therefore, it is possible that methane 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. As it is not possible to estimate an emission factor, emissions have been reported as “NE”.

#### *3) PFCs*

PFCs are emitted during aluminum refining.

#### *b) Methodological Issues*

● ***Estimation Method***

Estimating emissions involved multiplying the production volume of primary aluminum refining by Japan-specific emission factors calculated using the equation prescribed in the *Revised 1996 IPCC Guidelines*.

● ***Emission Factors***

The equation prescribed in the Tier 1b method of the *Revised 1996 IPCC Guidelines* was used to determine emission factors, which appear in the table below.

Table 4-25 PFCs emission factor of aluminum production

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| PFC-14 ($CF_4$) | kgPFC-14/t | 0.542 | 0.369 | 0.307 | 0.303 | 0.300 |
| PFC-116 ($C_2F_6$) | kgPFC-116/t | 0.054 | 0.037 | 0.031 | 0.030 | 0.030 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

- ***Activity Data***

As the activity data for PFC emissions in conjunction with aluminum refining we used the aluminum production volumes given in the Yearbook of Minerals and Non-Ferrous Metals Statistics compiled by the Ministry of Economy, Trade and Industry. Japan's primary aluminum production is small, at about 0.03% of world production.

#### *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% 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 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 Chemical and Bio Sub-Group, Ministry of Economy, Trade and Industry annually collects and estimates F gas emissions.

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

The data collected and estimated by the Chemical and Bio 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*

There have been no source-specific recalculations.

#### *f) Source-specific Planned Improvements*

No improvements are planned.

## 4.4.4. $SF_6$ Used in Aluminium and Magnesium Foundries (2.C.4.)

### 4.4.4.1. Aluminium

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

***a) Source/Sink Category Description***

$SF_6$ is emitted in magnesium foundries.

***b) Methodological Issues***

The data that has been reported is given in documentation prepared by the Chemical and Bio Sub-Group of the Ministry of Economy, Trade and Industry's Industrial Structure Council, for emissions of $SF_6$ used in magnesium foundries. The associated indices are given in the table below.

Table 4-26 Indices related to $SF_6$ used in magnesium foundries

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Consumption of $SF_6$ | t | 5 | 43 | 47 | 44 | 42 |
| Molten Magnesium | t | 1,840 | 14,231 | 21,200 | 26,852 | 25,392 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

***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***

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system[2], $SF_6$ emissions were recalculated for years 2003 to 2006

***f) Source-specific Planned Improvements***

No improvements are planned.

## 4.5. Other Production (2.D.)

### 4.5.1. Pulp and Paper (2.D.1.)

(According to the CRF, it is required to report on emissions of nitrogen oxides ($NO_X$), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC), and sulfur dioxide ($SO_2$).)

[2] The system based on the Law Concerning the Promotion of the Measures to Cope with Global Warming was enforced in 2006.

### 4.5.2. Food and Drink (2.D.2.)

Foods and drinks are manufactured in Japan, and because carbon dioxide is used in the manufacturing process (frozen carbon dioxide and raw material for carbonated drinks, etc.), it is conceivable that carbon dioxide is emitted into the atmosphere in the course of manufacturing. The carbon dioxide 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 Fuel Combustion Sector (1.A.), they have been reported as "IE".

## 4.6. Production of Halocarbons and $SF_6$ (2.E.)

This category covers HFCs,PFCs and $SF_6$ emissions from the manufacturing processes of production 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 2007, emissions from Production of Halocarbons and SF6 were 2,551 Gg-$CO_2$, and represented 0.2 % of GHG of the Japan's total GHG emissions. The emissions had decreased by 88.9 % compared to 1995.

### 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 interior of a reactor).

*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 4-27 Indices related to By-product Emissions of HFC-23: Production of HCFC-22

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Production of HCFC-22 | t | 81,000 | 95,271 | 65,715 | 65,905 | 61,197 |
| Rate of generation of HFC-23 | % | 2.13% | 1.70% | 1.90% | 1.94% | 1.82% |
| Emission rate for production | % | 1.79% | 1.11% | 0.06% | 0.09% | 0.03% |
| Emissions | t | 1,450 | 1,060 | 40 | 56 | 19 |
| | Mt$CO_2$eq. | 16.97 | 12.40 | 0.46 | 0.66 | 0.22 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

*Emissions were decreased because all manufacturing facilities had been equipped with a destruction unit.

### *c) Uncertainties and Time-series Consistency*

● ***Uncertainty***

For the uncertainty of the emission factor, 2% was applied, according to the *GL (2006)* 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).

### *e) Source-specific Recalculations*

There have been no source-specific recalculations.

### *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 manufacture.

### *b) Methodological Issues*

● ***Estimation Method***

Emissions were estimated based on the mass balance of measurement data at each of HFCs, PFCs, $SF_6$ manufacturing plants in Japan. Fugitive emissions in production from this source category were reported by subtracting the amount of production from the amount of HFCs, PFCs, $SF_6$ generated at each gas manufacturing facility. Emissions of HFCs for each year were given by the Japan Fluorocarbon Manufactures Association and of PFCs and $SF_6$ by Japan Chemical Industry Association.

The associated indices are given in the table below.

Table 4-28 Indices related to fugitive emissions from HFCs production

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| production of HFCs | t | 28,206 | 29,423 | 57,060 | 48,244 | 49,445 |
| emissions | Mt$CO_2$eq. | 0.480 | 0.258 | 0.353 | 0.281 | 0.280 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

Table 4-29 Indices related to fugitive emissions from PFCs production

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| production of PFCs | t | 1,207 | 2,336 | 2,726 | 3,211 | 3,216 |
| emissions | t | 107 | 181 | 107 | 112 | 99 |
| | Mt$CO_2$eq. | 0.763 | 1.359 | 0.837 | 0.879 | 0.783 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

Table 4-30 Indices related to fugitive emissions from $SF_6$ production

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| production of $SF_6$ | t | 2,392 | 1,556 | 2,313 | 2,787 | 2,723 |
| emissions | t | 197.0 | 39.0 | 33.0 | 69.0 | 53.2 |
| | $MtCO_2$eq. | 4.708 | 0.932 | 0.789 | 1.648 | 1.270 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

### 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 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*

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, HFCs emissions were recalculated for years 1995 to 2006.

### f） *Source-specific Planned Improvements*

No improvements are planned.

## 4.7. Consumption of Halocarbons and $SF_6$ (2.F.)

This category covers HFCs, PFCs and $SF_6$ emissions from the manufacturing, utilization and disposal processes of the products of Halocarbons and $SF_6$ 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.), Metered Dose Inhalers (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 2007, emissions from Consumption of Halocarbons and SF6 were 20,517 Gg-$CO_2$, and represented 1.5 % of GHG of the Japan's total GHG emissions. The emissions had decreased by 28.0 % compared to 1995.

### 4.7.1. Refrigeration and Air Conditioning Equipment (2.F.1.)

#### 4.7.1.1. Domestic Refrigeration (2.F.1.-)

***a） Source/Sink Category Description***

***1） HFCs***

HFCs are emitted from the production and use (including failure of devices) 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 refrigerant was refilled.

***b） Methodological Issues***

● ***Estimation Method***

The collected volume of HFC 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 volumes 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 production of devices.

*Emissions of HFCs from Domestic Refrigeration*

HFC emissions = total refrigerant contained from manufacturing × fugitive refrigerant ratio from production
+ ∑ (number of op erated devices containing HFC × refrigerant contained per operated device ×fugitive refrigerant ratio from use)
+ ∑ (number of disposed devices containing HFC × refrigerant contained per disposed device - collected volume of HFC

The associated indices are given in the table below.

Table 4-31 Indices related to emissions of HFCs from domestic refrigeration

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Total HFC Charged in the year | t | 520 | 590 | 33 | 11 | 9.6 |
| Fugitive refrigerant ratio | % | 1.00% | 1.00% | 0.17% | 0.05% | 0.00% |
| Number of operated devices | 1,000 devices | 7,829 | 33,213 | 41,796 | 39,754 | 37,225 |
| Refrigerant charged | g | 150 | 125 | 125 | 125 | 125 |
| Operational fugitive ratio | % | 0.3% | 0.3% | 0.3% | 0.3% | 0.3% |
| Disposed device | 1,000 devices | 0 | 177 | 1,839 | 2,314 | 589 |
| Collected volume of HFC | t/year | — | — | 55 | 68 | 195 |
| Emissions | t | 8.7 | 40 | 184 | 228 | 282 |
| | $MtCO_2$eq. | 0.011 | 0.052 | 0.240 | 0.296 | 0.366 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI
*: Calculated from current data

### *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*

There have been no source-specific recalculations.

### *f） Source-specific Planned Improvements*

No improvements are planned.

## 4.7.1.2. Commercial Refrigeration (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*

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 refrigerant was refilled.

### *b） Methodological Issues*

- ***Estimation Method***

In accordance with the IPCC Guidelines, emissions of each species of F-gases from 1) manufacturing, 2) installation, 3) operation and 4) disposal are estimated for devices below.

| |
|---|
| 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 |

*Emissions of HFCs from Commercial Refrigeration*

Methods below are applied to each type of device and refrigerant (HFCs)
1) manufacturing
Emissions from manufacturing = Σ (number of device produced × volume of refrigerant contained × fugitive refrigerant ratio from manufacturing)
2) installation
Emissions from operation = Σ (number of device charged refrigerant in place produced × volume of refrigerant contained × fugitive refrigerant ratio from installation)
3) operation
Emissions from maintenance = Σ (number of devices operated × volume of refrigerant contained × fugitive refrigerant ratio from operation) -volume collected
4) disposal
Emissions from disposal = Σ (number of devices disposal × average volume of refrigerant contained) -volume collected

* "number of devices operated" and "number of devices disposal" are estimated with volume of shipment and lifetime of device

The associated indices are given in the table below.

Table 4-32 Indices related to emissions of HFCs from commercial refrigeration

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| number of device produced | 1,000 | 222 | 380 | 1,413 | 1,339 | 1,391 |
| volume of refrigerant charged | g/device | 358 | 587 | 3,377 | 3,626 | 3,547 |
| fugitive refrigerant ratio | % | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| number of device charged refrigerant in place | 1,000 | 9 | 32 | 138 | 168 | 190 |
| volume of refrigerant | g/device | 17,806 | 9,221 | 23,914 | 26,073 | 25,170 |
| fugitive refrigerant ratio | % | 1.2% | 1.4% | 1.8% | 1.7% | 1.7% |
| number of devices operated | 1,000 | 375 | 1,957 | 6,770 | 7,884 | 8,983 |
| fugitive refrigerant ratio | % | 7.3% | 7.4% | 5.3% | 5.7% | 5.7% |
| number of devices disposal | 1,000 | 1 | 23 | 127 | 169 | 220 |
| collected volume of HFC | t/year | - | - | 172 | 200 | 149 |
| Emissions | t | 32.7 | 189.2 | 2,006.1 | 2,853.0 | 3,630.4 |
| | $MtCO_2$eq. | 0.042 | 0.283 | 3.523 | 5.168 | 6.880 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

* From 2002 onward, "number of device charged refrigerant in place produced" and "fugitive refrigerant ratio from operation" are increase because of device becoming larger with increasing commercial package AC device.

### 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 for all year were recalculated owing to the change in the estimation methodology. Additionally, the state of PFC use was ascertained, and PFC emissions during use changed to "NO."

### *f） Source-specific Planned Improvements*

No improvements are planned.

## 4.7.1.2.b. Automatic Vending machine

### *a） Source/Sink Category Description*

#### *1） HFCs*

HFCs are emitted from manufacturing, accident, and disposal 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 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 refrigerant was refilled..

### *b） Methodological Issues*

● ***Estimation Method***

Emissions of F-gases from 1) manufacturing, 2) accident and 3) disposal are estimated.

*Emissions of HFCs from Automatic Vender machine*

1) manufacturing
Emissions from manufacturing = Σ (number of device produced × volume of refrigerant contained
× fugitive refrigerant ratio from manufacturing)
2) accident
Emissions from accident = Σ (number of devices operated × volume of refrigerant contained
× incidence rate × average fugitive rate in accident)
3) disposal
(a) until 2001
Emissions from disposal = Σ {number of devices disposal × volume of refrigerant contained
× (1-collect rate) }
(b) from 2002 onward
Emissions from disposal = Σ (number of devices disposal × average volume of refrigerant contained)
-volume collected

The associated indices are given in the table below.

Table 4-33 Indices related to emissions of HFCs from automatic vender machines

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| number of device produced | 1,000 | 0 | 272 | 355 | 338 | 301 |
| volume of refrigerant | g | 0 | 300 | 220 | 219 | 219 |
| fugitive refrigerant ratio | % | - | - | 0.3% | 0.3% | 0.3% |
| number of devices operated | 1,000 | 0 | 284 | 1,999 | 2,337 | 2,638 |
| incidence rate | % | - | 0.00% | 0.34% | 0.33% | 0.32% |
| fugitive refrigerant ratio | % | - | 0% | 20% | 20% | 20% |
| fugitive refrigerant ratio | % | - | 0.00% | 0.53% | 0.50% | 0.48% |
| number of devices disposal | 1,000 | 0 | 0 | 0 | 0 | 183 |
| Emissions | t | 0.00 | 0.33 | 0.57 | 0.60 | 1.25 |
| | $MtCO_2eq.$ | 0.000 | 0.000 | 0.001 | 0.001 | 0.002 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

* Accident on devise charged with HFCs were almost never occurred in 1999 and 2000, then, reported as 0. After 2001 onward, accident occurred are considered with estimation.

#### *c) Uncertainties and Time-series Consistency*

● ***Uncertainty***

See section4.7.1.1. 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*

The state of PFC use was ascertained, and PFC emissions during use changed to "NO."

#### *f) Source-specific Planned Improvements*

No improvements are planned.

### 4.7.1.3. Transport Refrigeration (2.F.1.-)

#### *1) HFCs*

Emission was reported as "IE" since HFCs in this category had been included in the total reported in 4.6.1.2. Commercial Refrigeration and Air-conditioning Equipment section.

#### *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 refrigerant was refilled.

### 4.7.1.4. Industrial Refrigeration (2.F.1.-)

***1） HFCs***

HFCs emissions have been reported as "IE", as they are included in 4.6.1.2. Commercial Refrigeration (2F1-).

***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 refrigerant was refilled.

### 4.7.1.5. Stationary Air-Conditioning (Household) (2.F.1.-)

***a） Source/Sink Category Description***

***1） HFCs***

HFCs are emitted from the manufacturing, operation, accident, and disposal of household stationary air-conditioning.

***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 refrigerant was 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) disposal are estimated for devices below.

*Emissions of HFCs from Stationary Air-Conditioning (Household)*

1) manufacturing
Emissions from manufacturing = Σ (number of device produced × volume of refrigerant contained × fugitive refrigerant ratio from manufacturing)

2) operation
Emissions from operation = Σ (number of device for shipment × volume of refrigerant contained × fugitive refrigerant ratio from operation

3) disposal
Emissions from disposal = Σ (number of devices disposal × average volume of refrigerant contained) - volume collected

* "number of devices operated" and "number of devices disposal" are estimated with volume of shipment and lifetime of device

The associated indices are given in the table below.

Table 4-34 Indices related to emissions of HFCs(R-410a) from stationary air-conditioning (household)

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| number of device produced | 1,000 | 0 | 1,077 | 3,981 | 4,116 | 4,172 |
| volume of refrigerant | g | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |
| fugitive refrigerant ratio | % | 0.2% | 0.2% | 0.2% | 0.2% | 0.2% |
| number of devices operated | 1,000 | 0 | 1,726 | 26,091 | 33,238 | 40,356 |
| fugitive refrigerant ratio | % | 2% | 2% | 2% | 2% | 2% |
| collected volume of HFC | t/year | - | - | 9 | 17 | 35 |
| Emissions | t | 0 | 38 | 596 | 783 | 981 |
| | $MtCO_2$eq. | 0.000 | 0.066 | 1.029 | 1.351 | 1.693 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

***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 for all year were recalculated owing to the change in the estimation methodology.

***f) Source-specific Planned Improvements***

No improvements are planned.

#### 4.7.1.6. Mobile Air-Conditioning (Car Air Conditioners) (2.F.1.-)

***a) Source/Sink Category Description***

***1) HFCs***

HFCs are emitted from manufacturing, operation, maintenance, and accident of mobile air-conditioning.

***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 refrigerant was 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) maintenance, 4) accident and 5) disposal are estimated.

*Emissions of HFCs from Mobile Air-Conditioning (Car Air Conditioners)*

Methods below are applied to each type of cars

1) manufacturing
Emissions from manufacturing = Σ (number of device produced×volume of refrigerant contained ×fugitive refrigerant ratio from manufacturing)
2) operation
Emissions from operation = Σ (number of cars ×volume of refrigerant contained×fugitive refrigerant ratio from operation)
3) maintenance
Emissions from maintenance =Σ (number of cars operated×volume of refrigerant contained ×fugitive refrigerant ratio from maintenance)
4) accident
Emissions from accident =Σ (number of cars in complete collapse×volume of refrigerant contained)

5) disposal
(a) until 2001
Emissions from disposal =Σ {number of cars disposal×volume of refrigerant contained ×(1-collect rate) }
(b) from 2002 onward
Emissions from disposal =Σ (number of cars disposal×average volume of refrigerant contained) -volume collected

* “number of devices operated” and “number of devices disposal” are estimated with volume of shipment and lifetime of device

Table 4-35 Indices related to emissions of HFC-134a from car air conditioners

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| number of cars produced | 1,000 | 9,745 | 9,761 | 10,407 | 11,074 | 11,191 |
| fugitive refrigerant ratio | g | 4 | 4 | 3 | 3 | 3 |
| number of cars operated | 1,000 | 15,655 | 42,374 | 60,364 | 62,351 | 64,063 |
| volume of refrigerant charged | g | 700 | 615 | 548 | 536 | 536 |
| fugitive refrigerant volume | g | 15 | 15 | 10 | 10 | 10 |
| accident incidence | % | 4% | 4% | 4% | 4% | 4% |
| fugitive refrigerant ratio | % | 50% | 50% | 50% | 50% | 50% |
| number of cars in | 1,000 | 50 | 136 | 193 | 200 | 205 |
| average volume of refrigerant | g | 681 | 610 | 522 | 506 | 492 |
| number of cars disposal | 1,000 | 116 | 789 | 2,121 | 1,471 | 1,893 |
| average volume of refrigerant | g | 676 | 593 | 522 | 485 | 478 |
| collected volume of | t/year | - | - | 531 | 577 | 695 |
| Emissions | t | 605 | 1,759 | 2,239 | 1,803 | 1,873 |
| | $MtCO_2eq.$ | 0.787 | 2.287 | 2.910 | 2.344 | 2.435 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

### 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***

The state of PFC use was ascertained, and PFC emissions during use changed to “NO.”

***f) Source-specific Planned Improvements***

No improvements are planned.

## 4.7.2. Foam Blowing (2.F.2.)

### 4.7.2.1. Hard Foam (2.F.2.-)

#### 4.7.2.1.a. Urethane Foam (HFC-134a)

***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 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 emission “use” from that at the time of “disposal” because urethane foams were disposed of at various times. Accordingly, the emissions in both 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 to the previous year [t] × Percentage of annual emission during use [%]
= (Emission during production) + (Emission during use)

Table 4-36 Indices related to emissions of HFC-134a from urethane foam

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| HFC-134a Use | t | 0 | 167 | 224 | 259 | 216 |
| Leakage during foam blowing | % | 10% | 10% | 10% | 10% | 10% |
| Annual emissions rate | % | 4.5% | 4.5% | 4.5% | 4.5% | 4.5% |
| Emissions within the | t | 0 | 17 | 35 | 33 | 28 |
| Emissions during use | t | 0 | 0 | 44 | 54 | 65 |
| Emissions | t | 0.0 | 16.7 | 78.8 | 86.7 | 92.8 |
| Emissions during production | $MtCO_2$eq. | 0.000 | 0.022 | 0.046 | 0.043 | 0.036 |
| Emissions during use | $MtCO_2$eq. | 0.000 | 0.000 | 0.057 | 0.070 | 0.085 |
| Emissions | $MtCO_2$eq. | 0.000 | 0.022 | 0.102 | 0.113 | 0.121 |

Source: For HFC-134a Use, leakage during foam blowing, and annual emissions rate during use, Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

*: The amount of HFC-134a used in 1995-1999 was zero.

### *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 the similar category. For the uncertainties of the activity data, 50% was applied for both production and use, according to *GPG (2000)* 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*

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, HFC-134a emissions were recalculated for years 2003 to 2006.

### *f) Source-specific Planned Improvements*

No improvements are planned.

## 4.7.2.1.b. High Expanded Polyethylene Foam (HFC-134a, HFC-152) (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 4-37 Indices related to emissions of HFC-134a from polyethylene foam

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| HFC-134a Use | t | 346 | 322 | 128 | 120 | 120 |
| Emissions | t | 346 | 322 | 128 | 120 | 120 |
| | $MtCO_2eq.$ | 0.450 | 0.419 | 0.166 | 0.156 | 0.156 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

Table 4-38 Indices related to emissions of HFC-152a from polyethylene foam

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| HFC-152a Use | t | 14 | 0 | 0 | 0 | 0 |
| Emissions | t | 14 | 0 | 0 | 0 | 0 |
| | $MtCO_2eq.$ | 1.960 | 0.000 | 0.000 | 0.000 | 0.000 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

### *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*

There have been no source-specific recalculations.

### *f） Source-specific Planned Improvements*

No improvements are planned.

## 4.7.2.1.c. Extruded Polystyrene Foam （HFC-134a）(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 estimating method under PRTR for the amount of transferred HCFC at polystyrene foam production sites.

It is difficult to separate the emission "use" from that at the time of "disposal" because heat insulation material is disposed at various times such as the renovation and dismantle of buildings, and in a time of disaster. Since disposed polystyrene foam is considered to be emitting HFCs as well as that in use, these emissions are combined and reported under "use", while the emissions from "disposal" was 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 4-39 Indices related to emissions of HFC-134a from polystyrene foam

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| HFC-134a Use | t | 0 | 0 | 26 | 5 | 0 |
| Foam Productization rate | % | 75% | 75% | 75% | 75% | 75% |
| Annual emission rate | % | - | - | 2.5% | 2.5% | 2.5% |
| Emissions during production | t | 0 | 0 | 7 | 1 | 0 |
| Emissions during use | t | 0 | 0 | 67 | 31 | 31 |
| Emissions | t | 0 | 0 | 74 | 32 | 31 |
| Emissions during production | Mt$CO_2$eq. | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| Emission during use | Mt$CO_2$eq. | 0.00 | 0.00 | 0.09 | 0.04 | 0.04 |
| Emissions | Mt$CO_2$eq. | 0.00 | 0.00 | 0.10 | 0.04 | 0.04 |

Source: For HFC-134a Use, foam productization rate, and annual emissions rate during use, Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

The amount of HFC-134a used in 1995-2000 was zero.

### 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

There have been no source-specific recalculations.

### 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 HFC-23 fire extinguishers that HFC-23 is already filled in the bottles.

HFCs emission from this category was reported as “NO” by expert judgment since HFC-227ea was very small amount, 0.0007(t) (= 700g) when emission from production in FY2004 was estimated.

For 1996 and following years, calculations were performed using the following equation and based on the HFC extinguishing agent stock.

> *HFC emissions from use of fire extinguishers*
>
> HFC emissions [t] ＝ HFC extinguishing agent stocks [t] × Emission factor during use

Concerning the emission at the time of disposal of fire extinguishers, is reported as “NO” because the use of HFC for fire extinguishers has been just started, also the expected lifetime of buildings is 30-40 years, so it is unlikely to be disposed as of present time,

#### ● 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 Defense Agency), which are similar extinguishing agents, was adopted as the emission factor of this category.

Table 4-40 References for the Emission factor of fire extinguisher (The emission ratio of halon fire extinguisher)

| | Unit | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Average |
|---|---|---|---|---|---|---|---|---|
| Installations of halons 1301(A) | t | 17,094 | 17,090 | 17,060 | 16,994 | 17,075 | 16,889 | 17,034 |
| Refills of halons 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 of fire extinguishing agents using.

Table 4-41 The amounts of the HFC extinguishing agent stock

| | Unit | 1995 | 1996 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Stocks of HFC-23 | t | 0 | 16 | 306 | 478 | 481 | 496 |
| HFC-23 emissions | t | NO | 0.01 | 0.27 | 0.42 | 0.42 | 0.44 |
| | $MtCO_2eq.$ | NO | 0.16 | 3.15 | 4.92 | 4.96 | 5.11 |
| Stocks of HFC-227ea | t | 0 | 13 | 225 | 392 | 421 | 442 |
| HFC-227ea emissions | t | NO | 0.01 | 0.20 | 0.34 | 0.37 | 0.39 |
| | $MtCO_2eq.$ | NO | 0.03 | 0.57 | 1.00 | 1.07 | 1.13 |
| Total emissions | $MtCO_2eq.$ | NO | 0.20 | 3.73 | 5.92 | 6.03 | 6.24 |

### *c) Uncertainties and Time-series Consistency*

● ***Uncertainty***

For the uncertainties of the emission factors for the extinguisher using, 50% was applied, according to the values used in the 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 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..

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

The data received from the Fire Defense Agency is compiled by the Chemical and Bio Sub-Group, Ministry of Economy, Trade and Industry. And it is verified by the Committee for Greenhouse Gas Estimation Methods and is used in the inventory.

### *e) Source-specific Recalculations*

Because emissions from the use of extinguishing agents in Japan have been determined, emissions for 1996 and subsequent years were recalculated using that information.

### *f) Source-specific Planned Improvements*

No improvements are planned.

## 4.7.4. Aerosols/Metered Dose Inhalers (2.F.4.)

### 4.7.4.1. Aerosols (2.F.4.-)

### *a) Source/Sink Category Description*

HFCs are emitted from the manufacture 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 to the balance of the amount used for production and the actual measurement amount filled in the products, and it is included in the emissions. The amount used for production and the amount filled in the products were the data provided by the Aerosol Industry Association of Japan (AIAJ). HFC is considered to be actually remained in disposed aerosols on 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 4-42 Indices related to emissions of HFC-134a from aerosols

| Item | Unit | 1994 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Potential Emissions | t | 800 | 1,300 | 2,044 | 604 | 361 | 307 |
| Fugitive emissions* | t | - | - | 80.2 | 24.9 | 14.0 | 13.2 |
| emissions in the year | t | 400 | 650 | 1,022 | 302 | 180 | 154 |
| remaining | t | 400 | 650 | 1,022 | 302 | 180 | 154 |
| emissions | t | - | 1,050 | 2,137 | 908 | 497 | 347 |
| | $MtCO_2eq.$ | - | 1.365 | 2.778 | 1.181 | 0.646 | 0.452 |

※ under investigation

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

* Fugitive emissions from 1994 to 1997 are concluded in potential emissions.

Table 4-43 Indices related to emissions of HFC-152a from aerosols

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Potential Emissions | t | - | 34 | 1,300 | 1,438 | 1,193 |
| Fugitive emissions* | t | - | 1.1 | 28.9 | 40.6 | 123.8 |
| emissions in the year | t | - | 17 | 650 | 719 | 596 |
| remaining | t | - | 17 | 650 | 719 | 596 |
| emissions | t | - | 18 | 1,217 | 1,409 | 1,439 |
| | $MtCO_2eq.$ | - | 0.003 | 0.170 | 0.197 | 0.201 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

### 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*

There have been no source-specific recalculations.

### 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.

### 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 included mainly in destructed MDI because of 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 4-44 Indices related to emissions of HFC-134a from MDI

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Purchases of F-gas | t | - | 1.4 | 1.1 | 1.0 | 0.7 |
| Usage of domestic MDI | t | - | 1.4 | 0.9 | 0.9 | 0.6 |
| Usage of imported MDI | t | - | 42 | 71 | 69 | 60 |
| Amount of destroyed | t | - | 0.1 | 1.9 | 0.3 | 1.3 |
| Emissions | t | - | 37 | 63 | 70 | 64 |
| | $MtCO_2$eq. | - | 0.048 | 0.082 | 0.091 | 0.083 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

Table 4-45 Indices related to emissions of HFC-227ea from MDI

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Purchases of F-gas | t | - | 0.0 | 42.8 | 41.2 | 38.0 |
| Usage of domestic MDI | t | - | 0.0 | 41.0 | 39.4 | 36.2 |
| Usage of imported MDI | t | - | 3.6 | 2.1 | 1.4 | 0.7 |
| Amount of destroyed | t | - | 0.0 | 1.2 | 1.5 | 1.3 |
| Emissions | t | - | 1.8 | 48.1 | 42.3 | 39.3 |
| | $MtCO_2$eq. | - | 0.005 | 0.139 | 0.123 | 0.114 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

#### *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*

There have been no source-specific recalculations.

#### *f） Source-specific Planned Improvements*

No improvements are planned.

### 4.7.5. Solvents (2.F.5.)

#### *a） Source/Sink Category Description*

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 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 emission. Emission during production was reported as “IE” as it was believed to be included in “Fugitive Emissions (2.E.2)”. 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 disposed of, was emitted during use, because of the difficulty in determining the status of the disposal of PFCs; any disposal was not identified in 1995. The associated indices are given in the table below.

Table 4-46 Indices related to emissions of PFCs etc. from solvents

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| emissions | $MtCO_2eq.$ | 10.382 | 2.649 | 2.305 | 2.286 | 1.944 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

#### *c) Uncertainties and Time-series Consistency*

● ***Uncertainty***

For the uncertainties of the emission factors, 0% was applied for solvent using, 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***

See section 4.4.3. c).

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

See section 4.4.3. d).

#### *e) Source-specific Recalculations*

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, PFCs emissions were recalculated for years 1995 to 2006.

#### *f) Source-specific Planned Improvements*

No improvements are planned.

### 4.7.6. Other applications using ODS substitutes (2.F.6.)

Emission from this category was reported as "NE" since there is no actual data on emissions.

### 4.7.7. Semiconductors (2.F.7.)

#### 4.7.7.1. Semiconductors

#### *a) Source/Sink Category Description*

HFCs, PFCs and $SF_6$, are emitted from the manufacture of semiconductors.

#### *b) Methodological Issues*

● ***Estimation Method***

Methods of emissions from semiconductors are in line with IPCC guidelines. 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. Calculation on removal equipment is based on installation/or not, removal ratio of each technology.

In addition, regarding to treatment of 10% as residue of process supply rate, these emissions are

reported in this category in case of recharging of 90% and shipment. In cases of shipment after decomposition of residual 10% or cleansing containment shell, these emissions are reported in “2.E.2. Production of Halocarbons and $SF_6$”. In case of release to atmosphere, these emissions are almost reported in “2.E.2”.
Japan Electronics and Information Technology Industries Association (JEITA) data are used of mass of F-gases purchased.

Emissions from manufacturing (during F-gas charging to containment shell for shipment) are already reported in “2.E.2. Production of Halocarbons and $SF_6$”, then, are reported as “IE” for this category. Emissions from disposal can not be generated theoretically, therefore are reported as “NA”.

*F-gas emissions in Semiconductor Manufacturing*

Methods below are applied for each F-gas

(i) HFC-23, PFCs(PFC-14, PFC-116, PFC-218, PFC-c318), $SF_6$ emissions
F-gas emissions = purchases of F-gas (t) × process supply rate (%) × (1-use rate of F-gas)
× (1-fraction of F-gas destroyed (%)
× installation fraction of removal equipment (%) )
(ii) by-produced PFC-14 emissions
by produced PFC-14 emissions = purchases of PFC (t) × process supply rate (%)
× by-produced rate (%)
× (1-fraction of F-gas destroyed (%)
×installation fraction of removal equipment (%) )

Relevant indices are shown in Table below.

Table 4-47 Indices related to emissions of F-gas from manufacturing of semiconductors

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| PFC-14 purchased | t | 313.0 | 299.9 | 231.5 | 232.9 | 277.5 |
| PFC-116 purchased | t | 209.5 | 561.2 | 393.2 | 355.6 | 321.0 |
| PFC-218 purchased | t | 0.0 | 9.9 | 181.8 | 189.2 | 195.1 |
| PFC-c318 purchased | t | 0.6 | 38.6 | 24.8 | 28.3 | 33.4 |
| HFC-23 purchased | t | 47.8 | 49.4 | 42.1 | 48.6 | 62.1 |
| $SF_6$ purchased | t | 90.8 | 131.9 | 96.8 | 85.8 | 82.9 |
| process supply rate | % | 90% | 90% | 90% | 90% | 90% |
| use rate of PFC | % | 20%-80% (depending on kind of F-gases) | | | | |
| fraction of F-gas destroyed | % | 90% | 90% | 90% | 90% | 90% |
| $CF_4$ by-produced rate | % | $C_2F_6$（PFC-116）:10%、$C_3F_8$（PFC-218）:20% | | | | |
| by-produced $CF_4$ removal rate | % | 90% | 90% | 90% | 90% | 90% |
| HFC-23 emissions | Mt$CO_2$eq. | 0.158 | 0.172 | 0.136 | 0.149 | 0.161 |
| PFCs emissions | Mt$CO_2$eq. | 3.049 | 5.406 | 3.747 | 4.041 | 3.621 |
| $SF_6$ emissions | Mt$CO_2$eq. | 1.005 | 1.479 | 1.114 | 0.939 | 0.877 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI
*: use rate of PFC is default value of IPCC guidelines.

### 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 the 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*

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, HFCs, PFCs, and $SF_6$ emissions were recalculated for years 1995 to 2006.

### *f) Source-specific Planned Improvements*

No improvements are planned.

## 4.7.7.2. Liquid Crystals

### *a) Source/Sink Category Description*

HFCs, PFCs and $SF_6$, are emitted from the manufacture of liquid crystals.

### *b) Methodological Issues*

- ***Estimation Method***

Same methods applied to semiconductors are also applied to emissions from manufacturing of liquid crystals. World LCD Industry Cooperation Committee (WLICC) have been established voluntary action plan to reduce PFCs emissions and conducted reducing PFC emissions. In these activities, it should be applied IPCC methods.

Table 4-48 Indices related to emissions of F-gas from manufacturing of liquid crystals

| Item | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| PFC-14 purchased | t | 20.7 | 47.3 | 77.8 | 86.5 | 80.4 |
| PFC-116 purchased | t | 0.4 | 2.7 | 9.9 | 8.7 | 5.2 |
| PFC-c318 purchased | t | 0.0 | 0.0 | 0.8 | 1.2 | 2.0 |
| HFC-23 purchased | t | 0.1 | 0.7 | 1.6 | 1.6 | 1.7 |
| $SF_6$ purchased | t | 11.5 | 85.3 | 101.4 | 106.5 | 117.4 |
| use rate of PFC | % | 90% | 90% | 90% | 90% | 90% |
| fraction of F-gas destroyed | % | 20%-80% (depending on kind of F-gases) | | | | |
| $CF_4$ by-produced rate | % | 90% | 90% | 90% | 90% | 90% |
| by-produced $CF_4$ removal rate | % | $C_2F_6$ (PFC-116) : 10% | | | | |
| Desellection Efficiency of $CF_4$ | % | 90% | 90% | 90% | 90% | 90% |
| HFC-23 emissions | $MtCO_2$eq. | 0.000 | 0.002 | 0.003 | 0.003 | 0.003 |
| PFCs emissions | $MtCO_2$eq. | 0.099 | 0.233 | 0.155 | 0.164 | 0.120 |
| $SF_6$ emissions | $MtCO_2$eq. | 0.124 | 0.766 | 0.622 | 0.500 | 0.319 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

*: use rate of PFC is default value of IPCC guidelines.

### *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*

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, $SF_6$ emissions were recalculated for years 1995 to 2006.

### *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 manufacture 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. Emissions from the inspection and disposal of electrical equipment were obtained by actual measurements of $SF_6$.

In CRF, the emission was reported as "IE" after including the emission from disposal into the use of electrical equipment.

*$SF_6$ emissions from the production of electrical equipment*

$SF_6$ Emissions from the production of electrical equipment ＝ $SF_6$ purchased (t) ×assembly fugitive rate (%)

*$SF_6$ emission from the use of electrical equipment*

*$SF_6$ emission from the use of electrical equipment*

＝ Stocks of $SF_6$ × rate of emitted $SF_6$ to the environment during the use of electrical equipment (0.1%)

*$SF_6$ emission from the inspection of electrical equipment*

*$SF_6$ emission from the inspection of electrical equipment*＝ actual measurement of $SF_6$

*$SF_6$ emission from the disposal of electrical equipment*

*$SF_6$ emission from the disposal of electrical equipment* ＝ actual measurement of $SF_6$

The associated indices are given in the table below.

Table 4-49 Indices related to emissions of $SF_6$ from electrical equipment assembly

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| $SF_6$ purchsed | t | 1,380 | 649 | 629 | 595 | 619 |
| $SF_6$ charged to electrical equipment | t | 1,464 | 450 | 582 | 527 | 555 |
| stocks in other than electrical equipment | t | - | 105 | 29 | 54 | 47 |
| assembly fugitive rate | % | 29.0% | 14.6% | 2.8% | 2.4% | 2.7% |
| emissions | t | 400 | 100 | 23 | 19 | 20 |
| | $MtCO_2eq.$ | 9.560 | 2.402 | 0.548 | 0.460 | 0.482 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

Table 4-50 Indices related to emissions of $SF_6$ during the use of electrical equipment

| | Unit | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| stocks of $SF_6$ | t | 6,300 | 8,000 | 8,700 | 8,800 | 8,900 |
| operational fugitive rate | % | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| emissions | t | 60 | 27 | 17 | 23 | 18 |
| | $MtCO_2eq.$ | 1.445 | 0.648 | 0.394 | 0.554 | 0.441 |

Source: Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council, METI

#### 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)* 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

As a result of reviewing previous data based on the mandatory of greenhouse gas accounting and reporting system, $SF_6$ emissions were recalculated for years 1995 to 2006.

#### f) Source-specific Planned Improvements

No improvements are planned.

### 4.7.9. Other (2.F.9.)

In this category, the emission sources of $SF_6$ that is considered to be utilized for research purposes are recognized. Judging from the actual utilization practices, however, the emissions from the sources were considered to be more reasonable to be included in the category “2.F.8. The electric equipment”. Therefore, it is reported as “IE”.

**References**

IPCC, *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, 1997

IPCC, Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, 2000

IUPAC website “Atomic Weights of the Elements 1999” （http://www.chem.qmul.ac.uk/iupac/AtWt/AtWt9.html）

Ministry of the Environment Committee for the Greenhouse Gases Emissions Estimation Methods, GHGs Estimation Methods Committee Report Part 1, August 2006

Ministry of Economy, Trade and Industry, Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke

Ministry of Economy, Trade and Industry, Yearbook of Chemical Industries Statistics

Ministry of Economy, Trade and Industry, Documents of Group for prevention of global warming, Chemical and Bio Sub-Group, Industrial Structure Council

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Methanol and Formalin Association, Methanol Supply and Demand

# Chapter 5 Solvent and Other Product Use (CRF sector 3)

## 5.1. Overview of Sector

Emissions of $CO_2$, $N_2O$, and NMVOC are generated following the solvent and other product use. In this chapter, emissions due to the following product uses are estimated:

- Paint solvents
- Degreasing and dry-cleaning
- Chemical products
- Other products (e.g. anesthesia)

In 2007, total GHG emissions from the solvent and other product use sector amounted to approximately 245 Gg-$CO_2$ equivalent, accounting for 0.02% of national total emissions (excluding LULUCF) in Japan. In this sector, there were only a greenhouse gas emission source from “3.D.- Use of Nitrous Oxide for Anesthesia.

## 5.2. Paint Application (3.A.)

Paint solvents are used in Japan, but their application is basically restricted only to mixing and they are assumed not to take part in chemical reactions. Therefore, they do not generate $CO_2$ or $N_2O$. 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.)

(The Common Reporting Format (CRF) requires that emissions of NMVOC should be reported.)

## 5.5. Other (3.D.)

### 5.5.1. Use of Nitrous Oxide for Anesthesia (3.D.-)

#### *a) Source/Sink Category Description*

Nitrous oxide is emitted during anesthetics (laughing gas) use. Only $N_2O$ is used as a general anesthetic in Japan, and $CO_2$ is not used. Therefore, $CO_2$ emissions have been reported as "NA".

#### *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 import traders has been reported.

- ***Emission Factors***

It is assumed that all of the $N_2O$ used as a medical gas escapes into the atmosphere. Therefore, no emission factor has been established.

- ***Activity Data***

The number and volume of shipments of $N_2O$ for anesthetics (on calendar year basis) is given in the Ministry of Health, Labor and Welfare's Statistics of Production by Pharmaceutical Industry.

Table 5-1 Volume of shipments of general anesthetics on calendar year basis

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Laughing gas | kg | 926,030 | 1,411,534 | 1,099,979 | 859,389 | 789,558 | 789,558 |

#### *c) Uncertainties and Time-series Consistency*

- ***Uncertainty***

Because all $N_2O$ used for anesthetics are assumed to escape in 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 designated statistic based on statistical law, 5% uncertainty was given to 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*

The value for 2005 was updated because the most recent Statistics of Production by Pharmaceutical Industry gave shipment volume for 2006.

#### *f) Source-specific Planned Improvements*

Since there is no figure available concerning the amount of $N_2O$ destruction in Japanese hospitals, it is necessary to understand the destruction amount of $N_2O$ with the destruction unit for laughing gas

### 5.5.2. Fire Extinguishers (3.D.-)

#### *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 installed in the fire extinguisher in Japan. Therefore the $N_2O$ emissions from this category are reported as "NO".

### 5.5.3. Aerosol Cans (3.D.-)

#### *1） $CO_2$*

Aerosol products, which fills spray cans with carbon dioxide, are manufactured in Japan. It is assumed that the $CO_2$ could be emitted to 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".

#### *2） $N_2O$*

Aerosol products manufactured in Japan do not use $N_2O$. In principle, no $N_2O$ is emitted, too, and it has been reported as "NA".

### *References*

Ministry of Health, Labor and Welfare's *Statistics of Production by Pharmaceutical Industry*

Ministry of the Environment Committee for the Greenhouse Gases Emissions Estimation Methods, *Review of Greenhouse Gases Emissions Estimation Methods Part 2*, August 2002

# 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, methane gas generated and emitted by cattle, buffalo, sheep, goats, horses, and swine as the result of enteric fermentation is reported. In 4B: Manure Management, methane and nitrous oxide generated by treatment of manure excreted by cattle, buffalo, sheep, goats, horses, swine and poultry are reported. In 4C: Rice Cultivation, methane emissions from paddy fields (continuously flooded and intermittently flooded) cultivated for rice production are reported. In 4D: Agricultural Soils, methane and nitrous oxide emitted directly and indirectly from agricultural soil as well as pastures, ranges, and paddocks manure are reported. There is NO emission reported for 4E: Prescribed Burning of Savannas, since Japan has no emission source in this category, while methane and nitrous oxide (as well as carbon monoxide) 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.

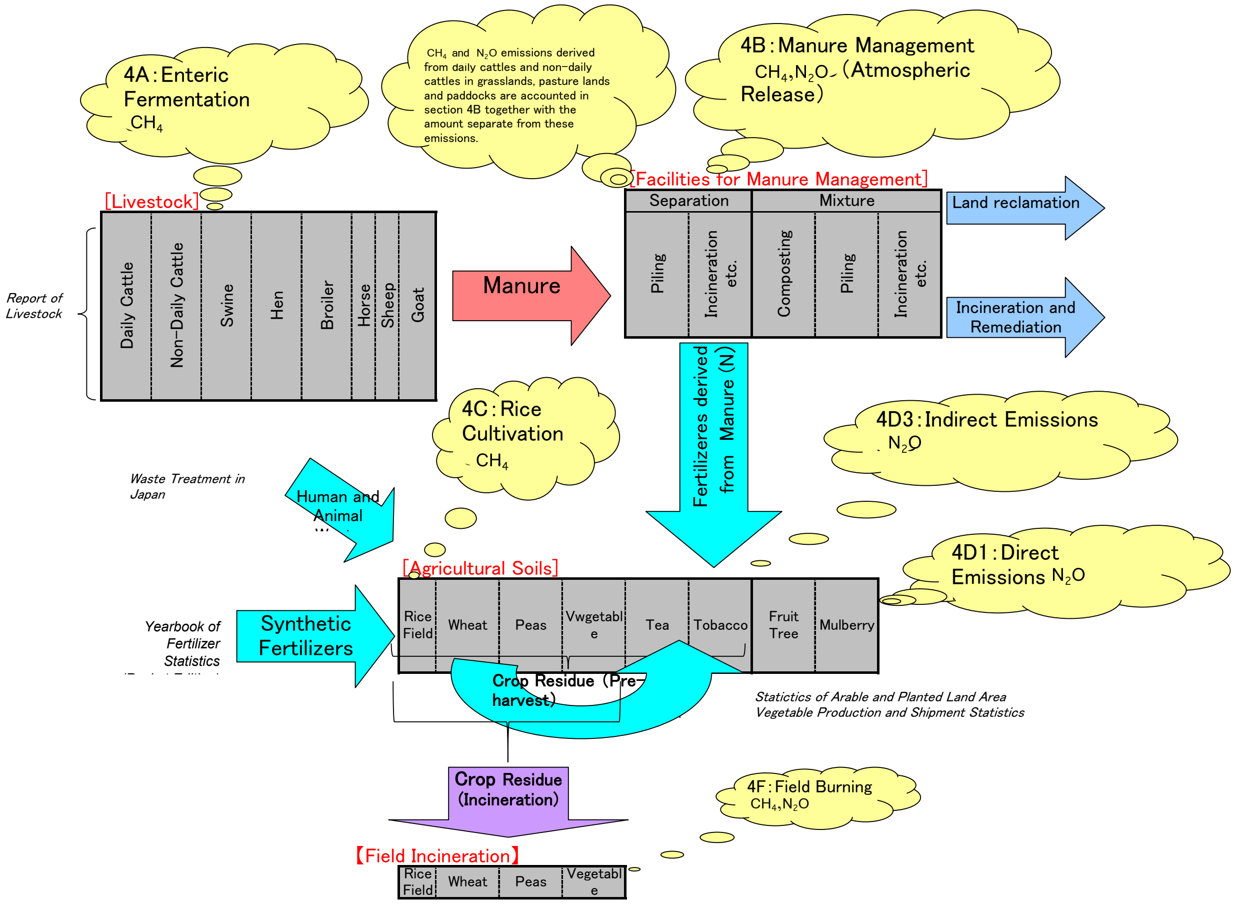


Fig. 6-1 Relationships among the categories in the agricultural sector

GHG emissions in the Agricultural Sector in FY 2007 were 26,546 Gg-$CO_2$, comprising 1.9% of total emissions. The value represents a reduction by16.0% from FY 1990.

## 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 methane emissions are calculated and reported in the *Enteric Fermentation (4.A.)* section.

GHG emissions from Enteric Fermentation in FY 2007 were 7,121Gg-$CO_2$, comprising 0.5% of total emissions. The Value represents a reduction by7.2% from FY 1990.

### 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 *Good Practice Guidance (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 methane conversion factor to derive the emission factor, but it has been in practice in Japan on livestock-related research to use volume of dry matter intake. It is considered that, by applying the results of previous researches, the estimation method using volume 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 methane 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 methane emissions associated with enteric fermentation includes cattle aged five months or older.

To reflect the actual situation of emissions in Japan, categorization of cattle is defined as shown below, and the estimation of methane emissions is conducted by type and age. (Refer to *4A-$CH_4$-2007.xls* for details of the calculation process.)

Table 6-1 Categorization and assumptions underlying calculation of methane emissions associated with enteric fermentation in cattle

| Animal type | | Assumptions for Calculation of Emissions |
|---|---|---|
| Dairy cattle | Lactating | — |
| | Non-lactating | — |
| | Heifers (under 2 years old, excluding 5- and 6-month olds) | Calculation excludes 6/24 of the population which was assumed to be 6 months or younger; therefore actually covering only 18/24 of the population 2 years or younger. |
| | Heifers (5 to 6 months old) | Calculation covers 5- and 6-month olds comprising 2/24 of the population under 2 years old. |
| Non-dairy cattle | Breeding cows (1 year and older) | — |
| | Breeding cows (under 1 year, excluding 5- and 6-month olds) | Calculation excludes 6/12 of the population which was assumed to be 6 months or younger; therefore covering 6/12 of the population under 1 year old. |
| | Breeding cows (5 and 6 months old) | Calculation covers 5- and 6-month olds comprising 2/12 of the population under 1 year old. |
| | Japanese cattle (1 year and older) | — |
| | Japanese cattle (under 1 year, excluding 5- and 6-month olds) | Calculation excludes 6/12 of the population which was assumed to be 6 months or younger; therefore covering 6/12 of the population under 1 year old. |
| | Japanese cattle (5 to 6 months old) | Calculation covers 5- and 6-month olds comprising 2/12 of the population under 1 year old. |
| | Dairy breeds (excluding 5- and 6-month olds) | Calculation excludes 6/24 of the population which was assumed to be 6 months or younger; therefore covering 18/24 of the population under 2 year old. |
| | Dairy breeds (5 to 6 months old) | Calculation covers 5- and 6-month olds comprising 2/24 of the population under 2 years old. |

●***Emission Factors***

The emission factor for methane 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 methane generated from dry matter intake.

Results of measurements have made it clear that it is possible to estimate methane 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 36).

Equation for estimating methane emissions associated with enteric fermentation in ruminant livestock

$$Y = -17.766 + 42.793 X - 0.849 X^2$$

Y : Volume of methane generated [l / day]
X : Dry matter intake [kg/day]

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-adjusted milk yield, body weight, and weight gain per day into the equation established for each type of cattle. Data for the fat-adjusted milk yield 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 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 per day 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).

> $CH_4$ Emission Factor of Enteric Fermentation (kg-$CH_4$/head)
> ＝(Methane generated [L/day/head]) / (Volume of 1 mol) × (molecular weight of methane) × (no. of days in year)
> ＝Y／22.4 (l/mol)×0.016 (kg/mol)×365or 366（day）

●***Activity Data***

The values used for activity data for this source are calculated by using the herd size for each type of livestock at 1 February in each year, recorded by the Ministry of Agriculture, Forestry and Fisheries in its *Livestock Statistics*.

Table 6-2 activity data associated with enteric fermentation by cattle (Single year)

| Item | | | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|---|
| Dairy Cattle | | Lactating | 1000 head | 1,082 | 1,035 | 971 | 900 | 871 | 862 | *862* |
| Dairy Cattle | | Dry | 1000 head | 332 | 299 | 249 | 231 | 221 | 213 | *213* |
| Dairy Cattle | | Heifer: Under Two Year, over six month | 1000 head | 491 | 445 | 379 | 379 | 375 | 344 | *344* |
| Dairy Cattle | | Heifer: Five and six month | 1000 head | 55 | 49 | 42 | 42 | 42 | 38 | *38* |
| Non-Dairy Cattle | Breeding Cows | One Year and Over | 1000 head | 679 | 646 | 612 | 593 | 607 | 634 | *634* |
| Non-Dairy Cattle | Breeding Cows | Under One Year, over six month | 1000 head | 17 | 13 | 12 | 14 | 14 | 17 | *17* |
| Non-Dairy Cattle | Breeding Cows | Fiveand six month | 1000 head | 6 | 4 | 4 | 5 | 5 | 6 | *6* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (M): One Year and Over | 1000 head | 368 | 412 | 385 | 374 | 392 | 407 | *407* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (M): Under One Year, over six month | 1000 head | 125 | 133 | 114 | 119 | 118 | 123 | *123* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (M): Fiveand six month | 1000 head | 42 | 44 | 38 | 40 | 39 | 41 | *41* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (F): One Year and Over | 1000 head | 197 | 265 | 246 | 291 | 291 | 309 | *309* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (F): Under One Year, over six month | 1000 head | 102 | 105 | 93 | 89 | 94 | 96 | *96* |
| Non-Dairy Cattle | fattening cattle | Wagyu cattle (F): Fiveand six month | 1000 head | 34 | 35 | 31 | 30 | 31 | 32 | *32* |
| Non-Dairy Cattle | fattening cattle | Dairy breed: Over six month | 1000 head | 805 | 808 | 845 | 789 | 798 | 800 | *800* |
| Non-Dairy Cattle | fattening cattle | Dairy breed: Five and six month | 1000 head | 89 | 90 | 94 | 88 | 89 | 89 | *89* |

** Data for 2008 are substituted by data for 2007*

## 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 statistical 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 FY 1990 onward by the method mentioned in the section on Emission Factors. Activity data were calculated consistently from FY 1989 onward from the data in Livestock Statistics.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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*

With the publication of *Japanese Feeding Standard: Dairy Cattle* (2006 edition) the formula for calculating the amounts of dry matter given to lactating cows and dry cows was updated, and FY2006 emissions were therefore changed.

In the agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### *f) Source-specific Planned Improvements*

- The *Good Practice Guidance (2000)* suggests that emission factors be calculated by multiplying the total country-specific gross energy intake by the $CH_4$ conversion factor. However, Japan estimates the emission factor by multiplying the volume of dry-matter by the $CH_4$ conversion factor, and the difference that may arise as a result of these two different estimating methods needs to be reviewed.
- It is anticipated that improvements in nutrition management techniques and techniques to suppress methane fermentation by controlling fermentation in the rumen (such as by the addition of fatty acid calcium and polyphenols to feed) will find increasing use, but estimation methods which can reflect them in emission is not developed although methane inhabitation amount changes by the component composition of feed, degrees and quantity of unsaturation for fatty acid calcium is not generated. It is necessary to develop estimation methods that can reflect measures to control methane generation.

## 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***

Methane emissions associated with enteric fermentation by buffalo, sheep, goats, swine, and horses were calculated using the Tier 1 Method in accordance with the Decision Tree of the *Good Practice Guidance (2000)*.

**●*Emission Factors***

The emission factor for methane associated with sheep and goats has been established in the same way as for cattle, based on the emissions of methane estimated from dry matter intake. The emission factor for swine has been established on the basis of results of research conducted in Japan. The emission factor used for horses and baffalo is the default value given in the *Revised 1996 IPCC Guidelines*.

Table 6-3 Emission factors for $CH_4$ associated with enteric fermentation in sheep, goats, horses and swine

| Animal type | Dry Matter Intake [kg] | $CH_4$ Generation factor [kg/year/head][a] |
|---|---|---|
| Sheep, goats | 0.8 | 4.1 |
| Swine[b] | − | 1.1 |
| Horses[c] | − | 18.0 |
| Buffalo[c] | − | 55.0 |

a: Calculated by the formula: (Methane generated [L/day/head]) / (Volume of 1 mol) × (molecular weight of methane) × (no. of days in year)

b: Mamoru Saito, *Methane emissions from fattening swine and expectant swine* (1988) (Reference 34)

c: *Revised 1996 IPCC Guidelines*

● ***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 1 February in each year, as recorded by the Ministry of Agriculture, Forestry and Fisheries in its *Livestock Statistics*. The values used for activity data for horses given in the *Statistical Document of Horse* offered by the Ministry of Agriculture, Forestry and Fisheries, for buffalo given *Statistics on Livestock in Okinawa Prefecture*.

Table 6-4 Activity data associated with enteric fermentation by buffalo, sheep, goats, swine, and horses

| Type of animal | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Sheep | 1000 head | 21 | 14 | 12 | 9 | 10 | *10* | *10* |
| Goats | 1000 head | 26 | 19 | 22 | 16 | 15 | *15* | *15* |
| Swine | 1000 head | 11,335 | 9,900 | 9,788 | 9,620 | 9,759 | 9,745 | *9,745* |
| Horse | 1000 head | 116 | 118 | 105 | 87 | 84 | *84* | *84* |
| Buffalo | 1000 head | 0.21 | 0.12 | 0.10 | 0.08 | 0.08 | 0.08 | *0.08* |

** Data for 2008 are substituted by data for 2007*

### 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 *Good Practice Guidance (2000)*. As the uncertainty for activity data, 0.83% of statistical 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-designated 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 FY 1990 to FY 2007. 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 FY 1989.

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

Refer to section ”6.2.1. Cattle ”.

#### *e) Source-specific Recalculations*

Until now, the values from FAO statistics had been used for the activity data of sheep, goats, and horses, butowing to a switch to using data provided by the Ministry of Agriculture, Forestry and Fisheries, which is national source and desirable, emissions for all years were updated.

In the agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

#### *f) Source-specific Planned Improvements*

Although the default emission factor in the *Revised 1996 IPCC Guidelines* or the *Good Practice Guidance (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 methane 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 *Good Practice Guidance (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, sheep, goats, horses, swine and poultry. Therefore, this category has been reported as “NO”.

## 6.3. Manure Management (4.B.)

Livestock manure generates methane when its organic content is converted to methane gas through methane fermentation, or when methane 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 FY 2007 are 2,394Gg-$CO_2$ and 4,861Gg-$CO_2$, comprising 0.2% and 0.4% of total emissions, respectively. The value represents a reduction by 22.9% and 14.1% from FY 1990, respectively.

### 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, swine and poultry. The estimations for cattle were conducted separately for “shedded” and “pastured” cattle. $CH_4$ emissions were reported in this category and $N_2O$ emissions for “pastured” were reported in “4.D.2 Psture, Range and Paddock Manure” .

#### *b）Methodological Issues*

#### *i) Calculation of Emissions (Cattle, Swine and Poultry in shed and barn)*

**●*Estimation Method***

Methane emissions associated with the treatment of manure excreted by cattle in a shed and barn (dairy and non-dairy), swine, and poultry (layers and broilers) were calculated by multiplying the volume of organic matter contained in manure from each type of livestock by the emission factor for each type of treatment method.

$$E = \sum \left( EF_n \times A_n \right)$$

$E$: Methane 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).

Nitrous oxide emissions associated with the management of manure excreted by cattle (dairy and non-dairy), swine, and poultry (layers and broilers) 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.

$$E = \sum \left( EF_n \times A_n \right) \times 44/28$$

$E$: Nitrous oxide 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 methane and nitrous oxide associated with Animal Waste Management System (hereafter, AWMS) of dairy cattle, non-dairy cattle, swine, hens, and broilers have been established for each treating method of for each type of livestock, on the basis of the results of research carried out in Japan after reviewing its validity in accordance with the decision tree shown in Figure 6-2. Actual values are given in the following tables.

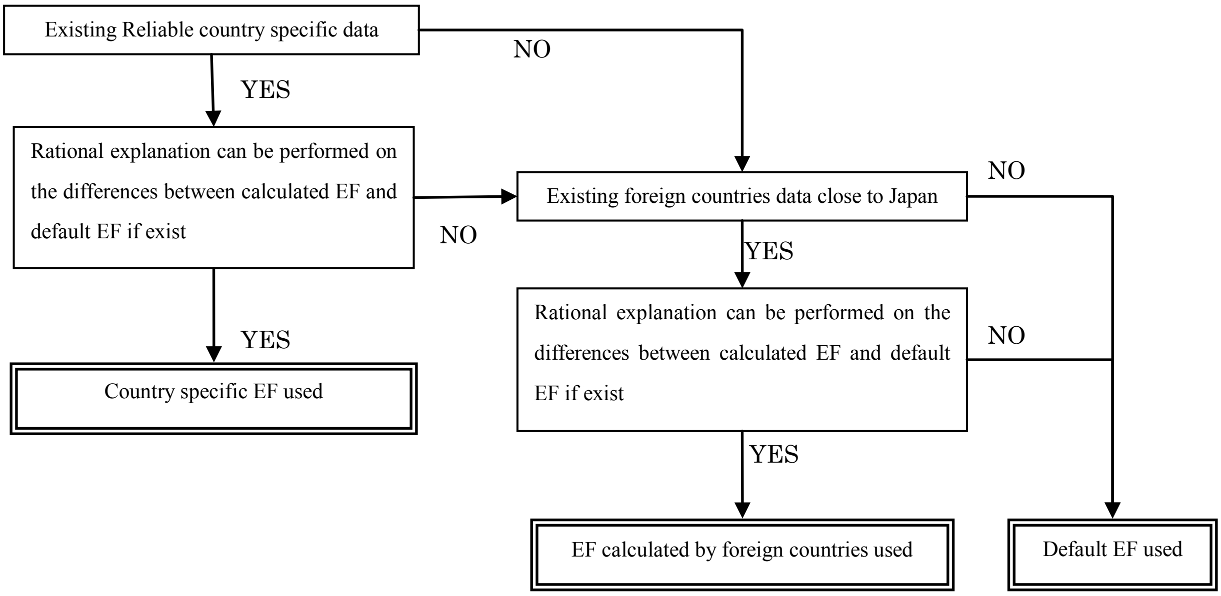


Figure 6-2 Decision tree for determination of EF

Table 6-5 $CH_4$ Emission factors for each method of treating manure from cattle, Swine, Hen & Broiler

| treating method | | Daily Cattle | | Non-daily cattle | | Swine | | Hen, Broiler | |
|---|---|---|---|---|---|---|---|---|---|
| 12. Pit storage | | 3.90 % | D[1] | 3.00 % | D[1] | 8.7 % | D[1] | — | — |
| 13. Sunlight drying | | 0.20 % | J[3] | 0.20 % | J[3] | 0.20 % | J[3] | 0.20 % | J[3] |
| 14. Other | 14a. Thermal drying | 0 % | Z[4] | 0 % | Z[4] | 0 % | Z[4] | 0 % | Z[4] |
| | 14b. Composting (feces) | 0.044 % | D[1] | 0.034 % | D[1] | 0.097 % | D[1] | 0.14 % | J[3] |
| | 14c. Deposition | 3.80 % | J[5] | 0.13 % | J[5] | 0.16 % | J[5] | 0.14 % | J[5] |
| | 14d. Incineration | 0.4 % | O[46] | 0.4 % | O[46] | 0.4 % | O[46] | 0.4 % | O[46] |
| | 14e. Composting (feces and urine mixed) | 0.044 % | D[1] | 0.034 % | D[1] | 0.097 % | D[1] | — | — |
| | 14f. Wastewater management | 0.0087% | D[1] | 0.0067% | D[1] | 0.019% | D[1] | — | — |

Table 6-6 $N_2O$ Emission factors for each method of treating manure from cattle, Swine Hen & Broiler

| treating method | | Daily Cattle | | Non-daily cattle | | Swine | | Hen, Broiler | |
|---|---|---|---|---|---|---|---|---|---|
| 12. Pit storage | | 0.10 % | | | | | | | D[1] |
| 13. Sunlight drying | | 2.0 % | | | | | | | D[1] |
| 14. Other | 14a. Thermal drying | 2.0 % | | | | | | | D[1] |
| | 14b. Composting (feces) | 0.25 % | | | | | | | J[7] |
| | 14c. Deposition | 2.40 % | J[5] | 1.60 % | J[5] | 2.50 % | J[5] | 2.0 % | D[1] |
| | 14d. Incineration | 0.1 % | | | | | | | O[4] |
| | 14e. Composting (feces and urine mixed) | 2.0 % | | | | | | | D[1] |
| | 14f. Wastewater management | 5.0 % | | | | | | | J[8] |

D: Default value of IPCC Guideline

J: Established by data of Japan

O: Established by data of other countries

Z: Emission can not occur because of mechanism

* Manure excreted by hen and broiler was categorized as feces since it contains a very small amount of urine.

*Sources for Table 6-5 and Table 6-6*

1: GPG (2000) (Reference 4)

2: IPCC, *Revised 1996 IPCC Guidelines* (Reference 3)

3: Makoto Ishibashiet. al, *"Development of technology of reducing GHG on the livestock industry(second report)"*

(2003) (Reference 38)

4: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*, (2002) (Reference 27)

5: Takashi Osada et.al, Greenhouse gas generation from livestock waste composting (2005) (Reference 42)

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 40)

8: Takashi Osada, Nitrous Oxide Emission from Purification of Liquid Portion of Swine Wastewater (2003) (Reference 41)

● ***Activity Data***

The values used for the activity data for emissions of methane and nitrous oxide associated with management of livestock excretion from dairy cattle, non-dairy cattle, swine, hens and broilers, are estimates of the volume of organic matter and the volume of nitrogen excreted annually by various types of livestock, respectively.

Total annual volume 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 volume of feces or urine excreted per head. The volume of organic matter and nitrogen amount was allocated to each category of manure management by multiplying the total volume by the percentage of manure treated separately and the percentage per treatment method. For livestock population, same references indicated in '4.A. Enteric Fermentation' are used.

*Estimating activity data for $CH_4$ (volume of organic matter excreted)*

Volume of organic matter excreted [Gg] ＝ Livestock herd or flock size [1000 head] × volume of feces or urine excreted [kg/head/day] × days per year [day] × proportion of organic matter in feces or urine [%] × proportions of feces and urine separated [%] × share of each treating method [%] × 1000

Source:
Livestock herd/flock: MAFF, *Livestock Statistics*
Volume of feces or urine excreted: Tsuiki et. al, A Computer Program for Estimating the Amount of Livestock Wastes. (1997) (Reference 45)
Proportion of organic matter in feces or urine: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 27)
Proportions of feces or urine separated: Same as above
Share of each treating method: Japan Livestock Technology Association, *GHGs emissions control in livestock Part4*, March 1999

*Estimating activity data for $N_2O$ (volume of nitrogen excreted by each type of livestock)*

Volume of nitrogen excreted [Gg-N] ＝ Livestock herd or flock size [1000 head]
× nitrogen content volume of feces or urine excreted [kg-N/head/day] × days per year [day]
× proportion of feces and urine separated [%] × share of each treating method [%]

Source:
Nitrogen content volume in feces or urine excreted: Tsuiki et. al, A Computer Program for Estimating the Amount of Livestock Wastes. (1997) (Reference 45)
Other elements of the equation are same as for methane.

➢ ***Cattle population***

In order to avoid duplication with the cattle under grazing, the cattle population was calculated by subtracting activity data for grazing cattle determined by the formula, “Grazing population × Number of grazing days (190 days) / Number of days in year (365 or 366 days)”, from the total population of dairy and non-dairy cattle.

Table 6-7 Feces and urine excreted, by type of livestock

| Type of livestock | | Volume of feces or urine excreted [kg/head/day] | | Nitrogen content volume in feces or urine excreted [gN/head/day] | |
|---|---|---|---|---|---|
| | | feces | urine | Feces | urine |
| Dairy Cattle | Lactating | 45.5 | 13.4 | 152.8 | 152.7 |
| | Dry and Inexperienced Birthing | 29.7 | 6.1 | 38.5 | 57.8 |
| | Heifer: Under Two Years | 17.9 | 6.7 | 85.3 | 73.3 |
| Non-Dairy Cattle | Under Two years | 17.8 | 6.5 | 67.8 | 62.0 |
| | Over Two Years | 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: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 27)

Table 6-8 Organic matter and nitrogen content in manure, by type of livestock（wet base）

| Type of livestock | Organic matter content | | Nitrogen content | |
|---|---|---|---|---|
| | Feces | Urine | Feces | Urine |
| Dairy Cattle | 16% | 0.5% | 0.4% | 0.8% |
| Non-Dairy Cattle | 18% | 0.5% | 0.4% | 0.8% |
| Swine | 20% | 0.5% | 1.0% | 0.5% |
| Hen | 15% | — | 2.0% | — |
| Broiler | 15% | — | 2.0% | — |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 27)

Table 6-9 Proportion of separated and mixed treatment of manure, by type of livestock

| Type of livestock | Separated | Mixed |
|---|---|---|
| Dairy Cattle | 60% | 40% |
| Non-Dairy Cattle | 7% | 93% |
| Swine | 70% | 30% |
| Hen | 100% | — |
| Broiler | 100% | — |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 27)

Table 6-10 Percentage of manure management by type of animal

| State of Manure (Separated or Mixed) | | Treating method | Dairy Cattle | Non-Dairy Cattle | Swine | Hen | Broiler |
|---|---|---|---|---|---|---|---|
| Separated | Feces | Sunlight drying | 2.8% | 1.5% | 7.0% | 30.0% | 15.0% |
| | | Thermal drying | 0.0% | 0.0% | 0.7% | 3.0% | 0.0% |
| | | Composting | 9.0% | 11.0% | 62.0% | 42.0% | 5.1% |
| | | Deposition | 88.0% | 87.0% | 29.6% | 23.0% | 66.9% |
| | | Incineration | 0.2% | 0.5% | 0.7% | 2.0% | 13.0% |
| | Urine | Composting | 1.5% | 9.0% | 10.0% | — | — |
| | | Wastewater management | 2.5% | 2.0% | 45.0% | — | — |
| | | Pit storage | 96.0% | 89.0% | 45.0% | — | — |
| Mixed | | Sunlight drying | 4.7% | 3.4% | 6.0% | — | — |
| | | Thermal drying | 0.0% | 0.0% | 0.0% | — | — |
| | | Composting | 20.0% | 22.0% | 29.0% | — | — |
| | | Deposition | 14.0% | 74.0% | 20.0% | — | — |
| | | Wastewater management | 0.3% | 0.0% | 22.0% | — | — |
| | | Pit storage | 61.0% | 0.6% | 23.0% | — | — |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Part4*. (1999) (Reference 25)

●***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 *Good Practice Guidance (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.

### *ii) Calculation of Emissions (Cattle under grazing)*

Organic matter contained in manure excreted by livestock during grazing (i.e. dung and urine deposited onto grazing and watering grounds by the grazing livestock) is converted to methane through the methane fermentation process, and emitted into the atmosphere. The nitrogen-containing manure also generates ammonium ions, which in turn generates nitrous oxide in the process of oxidation under aerobic conditions.

Emissions in this category are reported for cattle grazing owing to the unavailability of statistics and other information regarding the grazing of other animals. $CH_4$ emissions are reported in this category and $N_2O$ emissions from grazing cattle are reported in 4D2.

●***Estimation Method***

For methane and nitrous oxide emitted from pasture, range, and paddock manure, the amount of emissions was calculated for cattle by multiplying the Japan-specific emission factors by the total grazing population in accordance with the Decision Tree in the *Good Practice Guide (2000)* (page

4.55, Fig. 4.7).

●***Emission Factors***

Data for the amounts (g) of methane and nitrous oxide emitted from manure excreted per head of cattle per day were used as the emission factors. The data were established by multiplying the model output value of carbon content in manure excreted by grazing cattle during the grazing period by the actual measurement values of methane and nitrous oxide generated per amount of carbon contained in the manure of the grazing cattle.

The amount of carbon contained in the manure of the grazing cattle was calculated by a growth model of grazing cattle based on grass production, quality of grass, climatic conditions, and age in days of grazing cattle.

Table 6-11 Emission factors for animal production

| GHGs | Emission Factors | Unit |
|---|---|---|
| $CH_4$ | 3.67 | [g $CH_4$/head/day] |
| $N_2O$ | 0.32 | [g $N_2O$-N/head/day] |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Part.* (2001) (Reference 26)

●***Activity Data***

Activity data was determined by multiplying the grazing population by the duration of the grazing period. The grazing population was derived from the total grazing population in both public and private pastures reported in the *2004 Livestock Statistics*. For the grazing population in prior years, the percentage of the average grazing population (= Grazing population reported in the *Livestock Statistics* / Total population raised) as in FY 2003 and FY 2004 was determined first, and then the grazing population for each fiscal year was calculated on the assumption that the percentage was the same in all fiscal years.

The duration of 190 days was established for the grazing period, using the values for seasonal grazing (average grazing period: 172.8 days; the number of pastures 623) and year-round grazing (assumed grazing period: 365 days; the number of pastures 61) indicated in the *Report on National Factual Survey of Cattle Pastures (2000)*, and averaging the grazing days weighted by the number of pastures.

Table 6-12 Trends in the population of grazing cattle

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Amount of grazing daily cattle | head | 302,219 | 281,603 | 252,088 | 245,100 | 236,500 | 311,900 | *311,900* |
| Amount of grazing non-daily cattle | head | 99,734 | 103,162 | 99,759 | 116,300 | 98,500 | 134,500 | *134,500* |

** Data for 2008 are substituted by data for 2007*

### ***iii)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 6-11 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 volume 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 is 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 6-13 Correspondence between the Japanese and CRF manure management categories

<table>
<tr><th colspan="3">Japan</th><th rowspan="2">CRF</th><th rowspan="2">Description of Treatment</th></tr>
<tr><th colspan="2">Manure treatment</th><th>Manure management category</th></tr>
<tr><td rowspan="8">Separate treatment</td><td rowspan="5">Feces</td><td>Sun drying</td><td>13. Solid Storage and Dry Lot</td><td>Dried under sunlight to facilitate handling (for storage and odor prevention).</td></tr>
<tr><td>Thermal drying</td><td>14. Other (a. Thermal drying)</td><td>Dried by heat to facilitate handling.</td></tr>
<tr><td>Composting</td><td>14. Other (b. Composting)</td><td>Fermented for several days to several weeks with forced aeration and agitation in lidded or closed tanks.</td></tr>
<tr><td>Piling</td><td>14. Other (c. Piling)</td><td>Piling system is a method of composting methods. Piled about 1.5-2m height on compost bed or in shed to ferment for several months with occasional turning.</td></tr>
<tr><td>Incineration</td><td>14. Other (d. Incineration)</td><td>For volume reduction or disposal, and use as an energy source (e.g. chicken manure boiler).</td></tr>
<tr><td rowspan="3">Urine</td><td>Composting</td><td>14. Other (e. Composting (liquid))</td><td>Treated in an aeration storage tank.</td></tr>
<tr><td>Purification</td><td>14. Other (f. Purification)</td><td>Separate pollutants using aerobic microbes, such as activated sludge.</td></tr>
<tr><td>Storage</td><td>12. Liquid systems</td><td>Stored in a storage tank.</td></tr>
<tr><td colspan="2" rowspan="6">Mixed treatment</td><td>Sun drying</td><td>13. Solid Storage and Dry Lot</td><td>Dried under sunlight to facilitate handling.</td></tr>
<tr><td>Thermal drying</td><td>14. Other (a. Thermal drying)</td><td>Same as above, Thermal drying.</td></tr>
<tr><td>Composting</td><td>14. Other (e. Composting (liquid))</td><td>Solids are fermented for several days to several weeks with forced aeration and agitation in lidded or closed tank. Liquids are treated in an aeration storage tank.</td></tr>
<tr><td>Piling</td><td>14. Other (c. Piling)</td><td>Same as above, Piling.</td></tr>
<tr><td>Purification</td><td>14. Other (f. Purification)</td><td>Same as above, Purification.</td></tr>
<tr><td>Storage</td><td>12. Liquid systems</td><td>Stored in a storage tank (e.g. slurry storage).</td></tr>
</table>

### *iv) Nitrogen in Livestock Manure Applied to Agricultural Soil*

At present, calculation of the percentages of manure-derived organic fertilizer application in *4.D.2.: Indirect Emissions* uses the total nitrogen content of livestock manure less the amount of volatilization into the atmosphere and the amount treated by “Incineration” and “Purification” treatments through which nitrogen is completely eliminated. The portion disposed of in landfill as waste was also subtracted from the total nitrogen content in livestock manure. Buffalo, sheep, goats, and horses are excluded from the calculation because they produce very small amounts of manure and details of their management in Japan are unknown.

#### ●*Estimation Method*

The percentage of application of manure-derived organic fertilizers was calculated by subtracting the nitrogen contents in the livestock manure disposed of in the “direct final disposal”, the nitrogen volatized as nitrous oxide, the nitrogen volatilized as ammonia and nitrogen oxides, and the nitrogen eliminated by the “incineration” and “purification”, from the total nitrogen contained in livestock manure excreted in a shed and barn.

$$N_D = N_{all} - N_{N2O} - N_{NH3+NOx} - N_{inc+waa} - N_{waste}$$

| | |
|---|---|
| $N_{D:}$ | Amount of nitrogen in manure-derived fertilizer applied to agricultural soil (kg-N) |
| $N_{all:}$ | Total amount of nitrogen excreted by livestock (deposited in shed and barn) (kg-N) |
| $N_{N2O:}$ | Nitrogen in livestock manure volatilized as nitrous oxide (deposited in shed and barn) (kg-N) |
| $N_{NH3+NOx:}$ | Nitrogen in manure volatilized as $NH_3$ and $NO_X$ (deposited in shed and barn) (kg-$NH_3$-N + $NO_X$-N) |
| $N_{inc+waa:}$ | Nitrogen eliminated by "incineration" and "purification(deposited in shed and barn) (kg-N) |
| $N_{waste:}$ | Amount of nitrogen in manure that is disposed of in the "final direct disposal" (kg-N) |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary* (2002) (Reference 27)

- ***Amount of $N_2O$ volatilized into the atmosphere***

The amount of $N_2O$ volatilized into the atmosphere was determined from the calculation results of nitrous oxide emissions from livestock manure.

- ***Amount volatilized as ammonia and nitrogen oxides***

The amount of nitrogen that is volatilized as ammonia and nitrogen oxides from livestock manure was calculated by multiplying the nitrogen excreted by each type of animal by the percentage of nitrogen that is volatilized as ammonia and nitrogen oxides from manure of each type of animal. 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* (Japan Livestock Technology Association).

Table 6-14 Estimated percentage of volatilized ammonia from livestock manure

| Type of Animal | Value |
|---|---|
| Dairy and non-dairy cattle | 10% |
| Swine | 20% |
| Layers and broilers | 30% |

Source: Japan Livestock Technology Association, *GHGs emissions control in livestock Summary*. (2002) (Reference 27)

- ***Nitrogen eliminated by incineration or purification***

The amount was determined from the values of nitrogen disposed of through incineration and purification processes in manure management.

- ***Nitrogen in manure disposed of in direct final disposal***

Livestock manure disposed of in landfill as waste is either treated before disposal ("treated disposal") or sent directly to landfill untreated ("direct final disposal").

Because the manure that is disposed of in "direct final disposal" is detained as a mixture of dung and urine prior to the disposal in landfill, a portion of manure held under the Storage subcategory in the Mixed Treatment category was deemed to have been disposed of in "direct final disposal" (note: manure of layers and broilers was deemed to have been treated under the "Feces - Piling" subcategory. The amount of manure that is disposed of in "treated disposal" is negligible and its treatment method is unknown; therefore, manure that is treated before final disposal was included in the calculation of the manure disposed in the "direct final disposal".

For the amount of nitrogen in manure disposed of in "direct final disposal," the total amounts of manure disposed in the "direct final disposal" and "treated disposal" 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 apportioned to the volume of dung and urine of cattle and swine that was treated under the Storage subcategory of the Mixed Treatment category and the volume of manure of layers and broilers that was treated under the "Feces - Piling" of feces subcategory. The amounts that had been apportioned to the cattle and swine were further apportioned to dung and urine. Finally, the amounts of nitrogen content were calculated by multiplying the apportioned amounts by the nitrogen content calculated by dividing nitrogen amount in manure treated in storage system by manure amount treated in storage system in each of dung and urine of each type of animal (Table 6-6).

*Nitrogen content in livestock manure disposed in the direct final disposal*
= Volume disposed of per type of animal and feces/urine × Nitrogen content in feces/urine of the type of animal
＝Total amount of direct final disposal and treated final disposal × Average nitrogen contents in manure treated by storage system
＝Total amount of direct final disposal and treated final disposal × Nitrogen amount in manure treated by storage system / Manure amount treated by storage system

Table 6-15 Nitrogen in livestock manure applied to agricultural soil

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| the amount of N in animal manure ($N_{all}$) | tN | 780,948 | 739,397 | 701,343 | 676,486 | 685,699 | 679,326 | 677,435 |
| the amount of N2O-N released from animal( except Incineration method and Wastewater manage method) ($N_{N2O}$) | tN | 9,164 | 8,675 | 8,188 | 7,892 | 8,009 | 7,934 | 7,912 |
| the amount of NH3-N and Nox-N released from animal manure ($N_{NH3+Nox}$) | tN | 144,091 | 136,475 | 129,345 | 124,958 | 127,527 | 126,442 | 126,092 |
| the amount of N vanished by Incineration method and Wastewater manage method ($N_{inc+waa}$) | tN | 69,044 | 60,300 | 57,926 | 56,680 | 57,520 | 57,241 | 57,085 |
| the amount of N vanished by buryying in the ground. ($N_{waste}$) | tN | 16,625 | 14,529 | 13,588 | 15,367 | 15,600 | 15,751 | 15,752 |
| the amount of N used as fertilizer ($N_D$) | tN | 542,025 | 519,419 | 492,296 | 471,588 | 477,043 | 471,958 | 470,594 |

### c) Uncertainties and Time-series Consistency

**●*Uncertainties***

An uncertainty assessment was conducted for individual livestock categories. For cattle, uncertainty assessments were conducted separately for "shedded" and "pastured" cattle and both uncertainties combined. For the uncertainties of the emission factors for livestock, excluding pastured cattle, the values given in the *Good Practice Guidance (2000)* and the values calculated by expert judgment in accordance with the decision tree for uncertainty assessment, were applied.

For the uncertainties of emission factors for pastured cattle, the values calculated by expert judgment were applied in accordance with the decision tree for uncertainty assessment. For the uncertainties of the activity data, 0.83% (the standard error for swine given in the *Livestock Statistics*) was applied to swine, and 1.99% (the standard error for hens given in the *Livestock Statistics*) was applied to hens, and broilers. For cattle (total population), 5% is adopted, same as "6.2.1. Enteric Fermentation, Cattle". Activity data for pastured cattle is indicated in the Livestock Statistics, but statistical error is not indicated and it is difficult to judge applying above precision for cattle (total). Therefore, 50% was applied for pastured cattle in accordance with the decision tree of uncertainty.

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, 53% and 79% for Poultry, respectively. The uncertainty assessment methods are summarized in Annex 7.

● ***Time-series Consistency***

Emission factors were calculated consistently from FY 1989 onward by the method mentioned in the section on *Emission Factors*. Activity data were calculated consistently from FY 1989 onward from the data in *Livestock Statistics*.

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

Tier 1 QC activities have been conducted in accordance with the *Good Practice Guidance (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 factor. In the case, the factors of differences were analysed. QA/QC activities are summarised in Annex 6.1.

### *e） Source-specific Recalculations*

Owing to a switch to using values reflecting the actual condition for basic unit of manure to each livestock type, activity data for FY1989 to FY2006 were updated. In conjunction with that, emissions for FY1990 to FY2006 were also changed.

In the agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

Beginning with this report, the emissions of all years were changed because the $N_2O$ emissions from cattle manure in pasture, range and paddocks are counted in 4.D.2.

### *f） Source-specific Planned Improvements*

As research on actual emissions has been conducted by the organizations and agencies concerned, a review of emission factors and parameters will be implemented when the new data are obtained.

## 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*

### *1） $CH_4$*

● ***Estimation Method***

Methane emissions associated with the management of manure excreted by buffalo, sheep, goats, and horses were calculated using the Tier 1 method in accordance with the Decision Tree of the *Good Practice Guidance (2000)* (Page 4.33, Fig. 4.3).

| *Methane emissions associated with manure management (kg-$CH_4$)* |
|---|
| = Emission factor for animal (kg-$CH_4$/year/head) × Population of the animal |

●***Emission Factors***

The emission factors for methane associated with a management of manure from sheep, goats and horses are the default values for temperate zones in industrialized nations, given in the *Revised 1996 IPCC Guidelines*. For buffalo, the default value given for the temperate zone in Asia was used.

Table 6-16 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 | 2.0 | *Revised 1996 IPCC Guidelines*, Vol. 3, p. 4.13, Table 4-6 |

●***Activity Data***

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 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 6-4).

### 2） $N_2O$

●***Estimation Method***

$N_2O$ emissions associated with a management of the manure of sheep, goats and horses have been calculated, using the Tier 1 method in accordance with Decision Tree of the Good Practice Guidance (2000) (Page 4.41, Fig. 4.4) (Refer to 4B-$CH_4$-2007.xls for details of the calculation process.)

| *Nitrous oxide 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***

The emission factors for $N_2O$ associated with a management of manure from sheep, goats and horses are the default values for temperate zones in Asia & Far East, given in the *Revised 1996 IPCC Guidelines*.

Table 6-17 Emission factors for buffalo, sheep, goats and horses [kg-$N_2O$-N/kg-N]

| Manure Management Category | | Emission Factor [kg-$N_2O$-N/ kg-N] |
|---|---|---|
| 11. | Anaerobic Lagoons | 0.1% |
| 12. | Liquid Systems | 0.1% |
| 13. | Solid Storage and Dry Lot | 2.0% |
| 14.Other | a. Thermal Drying | 0.0% |
| | b. Compsting | 0.0% |
| | c. Piling | 0.0% |
| | d. Incineration | 0.0% |
| | e. Liquid Compsting | 0.0% |
| | f. Purification | 0.0% |
| | g. Daily Spread | 0.0% |
| | h. Pasture Range and Paddock | 2.0% |
| | i. Used Fuel | 0.0% |
| | j. Other system | 0.5% |

Source: *Revised 1966 IPCC Guidelines*, Vol. 3, page 4.121, Table B-1 (Reference 3)

●***Activity Data***

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 methane emissions were used.

Table 6-18 Amounts of nitrogen in manure excreted by buffalo, sheep, goats, and horses [kg-N/head/year]

| Type of Animal | Emission Factor [kg-N/head/year] |
|---|---|
| Buffalo* | 40 |
| Goats* | 40 |
| Horses* | 40 |
| Sheep | 12 |

Source: *Revised 1996 IPCC Guidelines*, Vol. 3, page 4.99, Table 4-20, 1 (Reference 3)

* Value for "Other animals" was used.

Table 6-19 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 | 0% | 0% | 0% | 0% |
| 13. | Solid Storage and Dry Lot | 14% | 0% | 0% | 0% |
| 14.Other | a. Thermal Drying | 0% | 0% | 0% | 0% |
| | b. Composting | 0% | 0% | 0% | 0% |
| | c. Piling | 0% | 0% | 0% | 0% |
| | d. Incineration | 0% | 0% | 0% | 0% |
| | e. Liquid Composting | 0% | 0% | 0% | 0% |
| | f. Purification | 0% | 0% | 0% | 0% |
| | g. Daily Spread | 16% | 0% | 0% | 0% |
| | h. Pasture, Range and Paddock | 29% | 83% | 95% | 95% |
| | i. Used as Fuel | 40% | 0% | 0% | 0% |
| | j. Other system | 0% | 17% | 5% | 5% |

***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 *Good Practice Guidance (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 from FY 1989 to FY 2007. Activity data were calculated consistently from FY 1989 onward 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 *Good Practice Guidance (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***

Until now, the values from FAO statistics had been used for the activity data of sheep, goats, and horses, but owing to a switch to using data provided by the Ministry of Agriculture, Forestry and Fisheries, which is national source and desirable, emissions for all years were updated.

***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.)

Methane is generated under anaerobic conditions by the action of microbes. Therefore, paddy fields provide favorable conditions for methane 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 FY 2007 are 5,654Gg-$CO_2$, comprising 0.4% of total emissions. The value represents a reduction by19.3% from FY 1990.

### 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 (complex drainage of ponded water) concept in the *IPCC Guidelines*. The diagram below presents the outline.

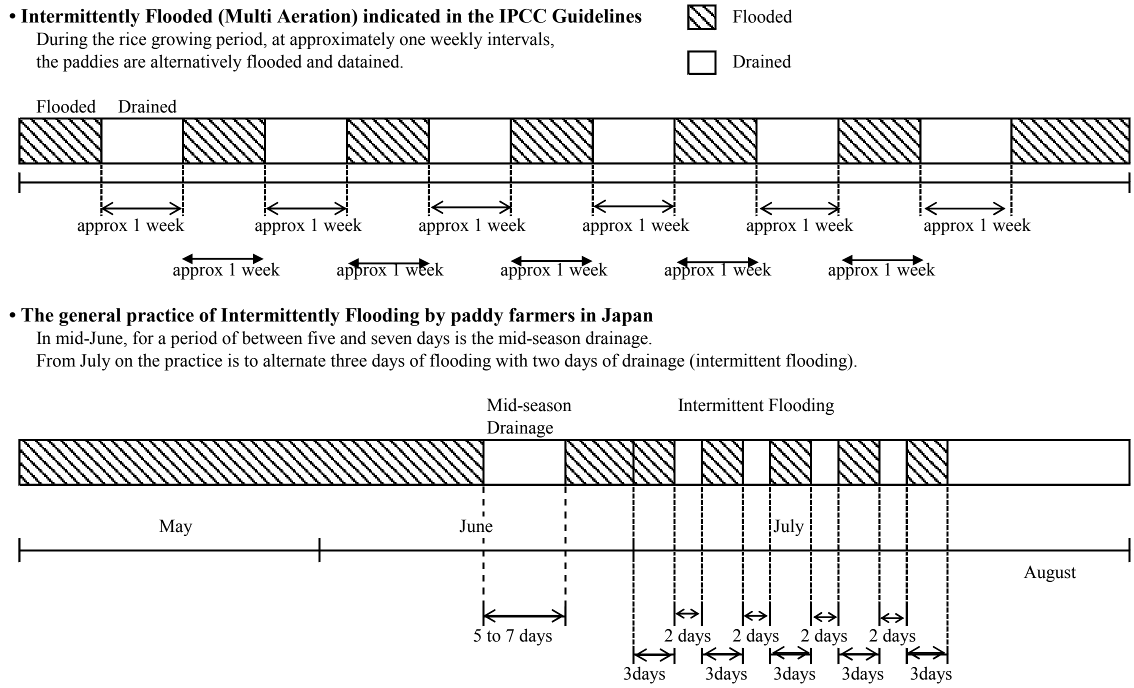


Figure 6-3 Comparison of water management regime in Japan and intermittent flooding (single aeration) indicated in the *IPCC Guidelines*

#### *b） Methodological Issues*

●***Estimation Method***

Methane emissions from intermittently flooded paddy fields (single aeration) were calculated by taking the overall usage of organic fertilizers into account, since the actual measurements of emission factors per soil type for each type of organic fertilizer application existed.

The amount of methane 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 methane generated per type of soil per unit area for each management method”, “percentage of the area of each type of soil”, and “percentage of each management method”.

<u>*Methane emission from intermittently flooded paddy fields (single aeration) (kg-$CH_4$)*</u>
= ∑ (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 × Percentage of soil type *m* × Percentage 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 methane emission of composted soil is 1.2 to 1.3 times more than that 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 6-20 Methane 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 33)

### ●*Activity Data*

It is assumed that intermittently flooded paddy fields (single aeration) comprise some 98% of planted paddy area and constantly flooded paddies[1] comprise the remaining 2%.

The method of establishing activity data for emissions of methane 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, and then by the proportion subject to organic mulch management.

Table 6-21 Proportion of Japan's surface area represented by specific soil types

| Type of soil | | Proportion of Japan's surface area |
|---|---|---|
| Andosol | Andosol, moist andosol, andosol gley soil | 11.9% |
| Yellow soil | Brown forest soil, gray ground soil, gley ground soil, yellow soil, dark red soil | 9.4% |
| Lowland soil | Brown lowland soil, grey lowland soil | 41.5% |
| Gley soil | Gley soil, strong gley soil | 30.8% |
| Peat soil | Black peat, peat soil | 6.4% |
| Total | | 100.0% |

Source: Ministry of Agriculture, Forestry and Fisheries, *Basic Survey of Ground Strength* (Reference 17)

1 *Revised 1996 IPCC Guidelines,* vol.2 Workbook, p4.18, Table 4.9

Table 6-22 Proportion of organic mulch management in Japan

| Organic amendment | Proportion |
|---|---|
| Straw amendment | 60% |
| Various compost amendment | 20% |
| No-amendment | 20% |

Source: Survey conducted by MAFF

Table 6-23 Area of paddy fields

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Area of paddy field | kha | 2,055 | 2,106 | 1,763 | 1,702 | 1,684 | 1,669 | 1,624 |

Source: *Statistics of Cultivated and Planted Area* (MAFF) (Reference 14)

### c) Uncertainties and Time-series Consistency

● ***Uncertainties***

The uncertainties for $CH_4$ emissions from intermittently flooded (multi aeration) paddy fields are assessed with respect to each organic mulch management regime (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 *Good Practice Guidance (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, 0.34% 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 no-amendment and 46% for various compost 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 *Good Practice Guidance (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 agricultural sector, 3-year average values have been used for estimation and report. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### f) Source-specific Planned Improvements

The Ministry of Agriculture, Forestry and Fisheries is currently conducting a comprehensive study aimed at agricultural land including the current conditions of organic material applications in paddy fields. There will be a review to be conducted on the estimation methods and parameter, such as the ones for the percentages of organic materials used when the 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***

Methane emissions from continuously flooded paddies 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 *Good Practice Guidance (2000)* (Page 4.79, Fig. 4.9). (Refer to *4C-$CH_4$-2007.xls¥ Continuously Flooded* for details of the calculation process.)

**●*Emission Factors***

Research results[2] in Japan indicate that emissions of methane 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 methane from constantly flooded paddy fields: divide the nominal emission factor for intermittently flooded paddy fields by 0.565 (1-0.435).

Table 6-24 Emission factor for methane from constantly flooded paddy fields

| Type of paddy field | Emission Factors [$gCH_4/m^2/year$] |
|---|---|
| Intermittently flooded paddy fields (mid-season drainage) | 15.98* |
| Constantly flooded paddy fields | 28.29 |

* : 3.4.C.1 Implied emission factor for intermittently flooded paddy fields (single aeration)

**●*Activity Data***

It is assumed that intermittently flooded paddy fields (single aeration) comprise some 98% of planted paddy area and constantly flooded paddies comprise the remaining 2%.

The method of establishing activity data for emissions of methane from constantly flooded paddy fields was to multiply the planted paddy area given in the Ministry of Agriculture, Forestry and Fisheries 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, 0.34% of standard error for area of

2 Kazuyuki Yagi, *Establishment of GHGs reduction model*, Incorporated foundation, Society for the Study of Agricultural Technology: "A Report on an Investigation of how to quantify the amount of Greenhouse Gases Emissions reduced in 2000F.Y. " p.27

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***

Refer to section “6.4.1. Intermittently Flooded”.

***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 IRRI (International Rice Research Institute) *World Rice Statistics 1993–94*, rain-fed paddy fields and wet bed methods 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 IRRI (International Rice Research Institute) *World Rice Statistics 1993-94*, a possible source of emissions in this category is upland crop paddies, but since upland crop paddies are not flooded, like the soil of fields, they are acidic and do not become anaerobic. The bacteria that generate methane are definitely anaerobic, and unless the soil is maintained in an anaerobic state, there will be no generation of methane.  As generation of methane 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 nitrous oxide in the process of oxidizing the ammonium ions into nitrate-nitrogen under aerobic conditions. $N_2O$ is emitted via denitrification of nitrate. Nitrous oxide 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 material 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 put of the air by rain. In this section, the amount of nitrous oxide generated by microbe activity on the deposited nitrogen compounds was calculated.

Nitrous oxide is generated by the action of microbes on nitrogen that leaches or runs off as nitrate from synthetic fertilizers and manure-derived materials applied to agricultural soil.

$N_2O$ emissions from agricultural soils in FY 2007 are 6,337Gg-$CO_2$, comprising 0.5% of total emissions. The value represents a reduction by 20.1% from FY 1990.

### 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***

Nitrous oxide emissions associated with the application of synthetic fertilizer to farmland soil (field lands) were calculated, using country-specific emission factors, and in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page. 4.55 Fig. 4.7) (Refer to *4D-N₂O-2007.xls¥S-Fertilizer(dry)* for details on the calculation process).

<u>*Nitrous oxide emissions associated with the application of synthetic fertilizer in agricultural soil (upland fields) (kg-$N_2O$)*</u>
= Emission factor [kg-$N_2O$-N/kg-N] × Amount of nitrogen contained in synthetic fertilizer applied in upland farming [kg-N] × 44/28

**●*Emission Factors***

Emission factors for nitrous oxide associated with the application of synthetic fertilizers to farmland soil (field lands) were established based on actual data measurement conducted in Japan. The emission factor is also used for organic Fertilizer

Emission factors for nitrous oxide associated with the application of synthetic fertilizers and organic fertilizers was defined as the same value, because there was no the significant difference between emission factors of synthetic fertilizers and organic fertilizers, analyzing data on $N_2O$ emissions from Japanese agricultural fields.

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 that of other crop. Thus, 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.

Table 6-25 $N_2O$ emission factor for synthetic fertilizer to agricultural soil

| Crop species | Emission Factor（$kgN_2O$-N/kgN） |
|---|---|
| Paddy rice | 0.31 % |
| Tea | 2.9 % |
| Other species | 0.62 % |

（Reference）Akiyama et. al, Direct $N_2O$ emissions and estimate of $N_2O$ emission factors from Japanese agricultural soils. (2006) (Reference 43)

Akiyama et. al, Direct $N_2O$ emissions and estimate of $N_2O$ emission factors from agricultural soils in Japan (2006) (Reference 44)

●***Activity Data***

For coordination with the way emission factors have been set, the amount of synthetic fertilizer used by crop type is used as the activity data of $N_2O$ emissions arising from the application of synthetic fertilizers to agricultural soil. The amount of synthetic fertilizer used can be ascertained from statistical information on the total amount used, but because there are no data enabling one to determine the annual amounts applied by crop type, values corresponding to the amounts of nitrogen applied for each crop type are found by taking the area of land planted with each crop type that can be found using statistical information and multiplying by the results of studies on the amounts of synthetic fertilizers applied per unit area for each crop type in Japan. Total chemical fertilizer demand is apportioned to each crop type in accordance with the corresponding application amount for each crop type.

Activity data for $N_2O$ emissions from the application of synthetic fertilizers to dry fields

Volume of nitrogen-based fertilizer applied to agricultural soil of each crop field [t]
= Demand for nitrogenous fertilizer [t] × (Area of each crop field [ha] × Amount of nitrogenous fertilizer used in each crop field [kg/10a]) / (Σ Area of each crop field [ha] × Amount of nitrogenous fertilizer used in each crop field [kg/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 years.

Because of regulations and other factors, fertilizer application amounts for tea change from year to year. Nonaka (2005) (Reference 49) has found the amounts of nitrogen applied to tea fields (the total of synthetic and organic) in 1993, 1998, and 2002. For these application amounts, the ratio of synthetic fertilizer to organic fertilizer applied to tea according to the 2000 study (Reference 28) was used to estimate the amounts of synthetic and organic fertilizer applied, which were then used in calculations. 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 6-29). For paddy rice, the report uses application amount data for years that can be determined using Statistical Survey on Farm Management and Economy (Ministry of Agriculture, Forestry and Fisheries).

Table 6-26 Demand for nitrogenous fertilizer

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Demand for Nitrogenous Fertilizer | tN | 611,955 | 527,517 | 487,406 | 471,190 | 448,581 | *448,581* | *448,581* |

** Data for 2007 and 2008 are substituted by data for 2006*

Table 6-27 Amount of synthetic fertilizers application per area by each type of crop (other than rice)

| 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 |

Table 6-28 Amount of synthetic fertilizers application per area (rice and tea)

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Amount of synthetic fertilizers application per area (rice) | kg-N/10a | 9.65 | 8.71 | 7.34 | 6.62 | 6.46 | 6.27 | *6.27* |
| 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 |

** The data of rice for 2008 are substituted by the data for 2007*

Table 6-29 Area of cropping by each type of crop

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Vegetables* | ha | 620,100 | 564,400 | 524,900 | 476,300 | 471,200 | 468,000 | *468,000* |
| Rice | ha | 2,055,000 | 2,106,000 | 1,763,000 | 1,702,000 | 1,684,000 | 1,669,000 | 1,624,000 |
| Fruit* | ha | 346,300 | 314,900 | 286,200 | 265,400 | 261,800 | 258,400 | *258,400* |
| Tea | ha | 58,500 | 53,700 | 50,400 | 48,700 | 48,500 | 48,200 | 48,000 |
| Potatoes* | ha | 115,800 | 104,400 | 94,600 | 86,900 | 86,600 | 87,400 | *87,400* |
| Pulse* | ha | 256,600 | 155,500 | 191,800 | 193,900 | 194,500 | 191,300 | *191,300* |
| Feed crops | ha | 1,096,000 | 1,013,000 | 1,026,000 | 1,030,000 | 1,018,000 | 1,012,000 | 1,012,000 |
| Sweet potato | ha | 60,600 | 49,400 | 43,400 | 40,800 | 40,800 | 40,700 | 40,700 |
| Wheat | ha | 366,400 | 210,200 | 236,600 | 268,300 | 272,100 | 264,000 | 265,400 |
| Coarse cereal (including Buckwheat)* | ha | 29,600 | 23,400 | 38,400 | 45,900 | 46,100 | 47,400 | *47,400* |
| Mulberries | ha | 59,500 | 26,300 | 5,880 | 2,998 | 2,665 | 2,363 | 2,011 |
| Industrial crops | ha | 142,900 | 124,500 | 116,300 | 110,300 | 109,300 | 108,130 | 108,330 |
| Tobacco* | ha | 30,000 | 26,400 | 24,000 | 19,100 | 18,500 | 17,670 | *17,670* |

** Data for 2008 are substituted by data for 2007*

| data | references |
|---|---|
| Demand for nitrogenous fertilizer | *Yearbook of Fertilizer Statistics (Pocket Edition)* |
| Amount of synthetic fertilizers application per area (rice) | Ministry of Agriculture, Forestry and Fisheries: *"Reserch of agricultural management"* |
| Amount of synthetic fertilizers application per area (tea) | Kunihiko Nonaka (2005) (References 49), *Establishment of GHGs reduction model, Incorporated foundation, Society for the Study of Agricultural Technology*(2002), (References 28) |
| Amount of synthetic fertilizers application per area by each type of crop (other than rice and tea) | *Establishment of GHGs reduction model, Incorporated foundation, Society for the Study of Agricultural Technology*(2002), (References 28) |
| Area of cropping: Vegetables, rice, Fruit, Tea, Pulse, Feed crops, Sweet potato, Wheat, Buckwheat, Mulberries(-2001), Industrial crops | *MAFF, Statistics of Cultivated and Planted Area*<br>*Note: The values of "Vegetable" is excluded "Potatoes", "Industrial crops" is excluded "Tea" and "Tobacco"* |
| Area of cropping: Potatoes | *MAFF, Vegetable Production and Shipment Statistics* |
| Area of cropping: Tobacco | *JT Survey* |
| Mulberries(2002-) | *MAFF Survey* |

### 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, 0.33% for paddy rice and 0.27% 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 *Good Practice Guidance (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

Although the same value had been used for the amount of fertilizer applied per unit area of tea for the previous year. However, now the data which reflect year-to-year changes are used for this report and will be used hereafter. Because synthetic fertilizer application amounts are apportioned to each crop type in a top-down manner in this category, emission amounts for each crop type in all years were updated when revising amounts applied per unit area of tea.

Additionally, because the agriculture sector uses three-year averages, FY2006 emission recalculation results are influenced by FY2007 revisions and updates of activity data for each crop type.

### f) Source-specific Planned Improvements

The same emission factor has been used for synthetic and organic fertilizers. Thus, it is a 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.

### b) Methodological Issues

● ***Estimation Method***

Emissions of nitrous oxide associated with the application of organic fertilizer (livestock and other compost and barnyard manure) to agricultural soils have been calculated using the country-specific emission factors, in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 4.55, Fig. 4.7).

(Refer to *4D-$N_2O$-2009.xls¥AnimalWaste* for detail on the calculation process.)

*Calculation of $N_2O$ emissions from the application of organic fertilizers to agricultural soils*

Volume of $N_2O$ emissions from the application of livestock manure (kg-$N_2O$)
= $\Sigma_{\text{Type of crop}}$ {Emission factor by type of crop (kg-$N_2O$-N/kg-N)
×Volume of nitrogen applied, by type of crop (kg N)} ×44/28

## ●*Emission Factors*

The same country specific emission factor used for synthetic fertilizer is used.

## ●*Activity Data*

Activity data for nitrous oxide emission associated with the application of organic fertilizers to agricultural soils was derived by multiplying the area of cultivation for each type of crop, by the volume of nitrogen applied per unit area for each type of crop (excluding tea). Because of regulations and other factors, fertilizer application amounts for tea change from year to year, same as the synthetic fertilizers. Nonaka (2005) (Reference 49) has found the amounts of nitrogen applied to tea fields (the total of synthetic and organic) in 1993, 1998, and 2002. For these application amounts, the ratio of synthetic fertilizer to organic fertilizer applied to tea according to the 2000 study (Reference 28) was used to estimate the amounts of synthetic and organic fertilizer applied, which were then used in calculations. 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 6-31). Area of cultivated land by type of crop is same as synthetic fertilizers.

Volume of nitrogen applied, by type of crop (kg-N)
= Area of cultivated land by type of crop (ha)
×Volume of nitrogen as organic fertilizer applied per unit area, by type of crop (kg-N/10a) ×10

Table 6-30 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 |
| 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 |

Table 6-31 Amount of nitrogen as organic fertilizers application per area for tea

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| 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 |

| Data | Source |
|---|---|
| Amount of nitrogen applied per unit area, by type of crop (excluding tea) | *Establishment of GHGs reduction model, Incorporated foundation, Society for the Study of Agricultural Technology, A Report on an Investigation of how to quantify the amount of Greenhouse Gases Emissions reduced in 2000F.Y. (Reference 33)* |
| Amount of nitrogen applied per unit area for tea | *Total amount: Nonaka (2005) (Referenace 49)* |

### 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 *Good Practice Guidance (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

Same as application of synthetic fertilizers, revision of the amount of the fertilized nitrogen per area for tea and revision and update of the activity data for FY 2007 are conducted. As a result, emissions are recalculated for all year.

In the agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### f) Source-specific Planned Improvements

Refer to section *6.5.1.1. Synthetic Fertilizers*.

## 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.

$$E = EF * F_{BN} * 44/28$$

E : $N_2O$ emission associated with N-fixation by N-fixing crops (kg-N2O)
EF : Emission factor (kg$N_2O$- N/kgN)

$F_{BN}$ : Amount of nitrogen fixed by N-fixing crops (kgN)

● ***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 6-25), 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) soybeans, adzuki beans, kidney beans, and peanuts, and the vegetables 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 (200) 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.

$$F_{BN} = \sum_i \left[ Crop_{BFi} \bullet (Frac_{NCRBFi} + Frac_{NRESBFi}) \right]$$

$F_{BN}$ : The amount of nitrogen fixed by N-fixing crops (kgN)
$Crop_{BFi}$ : Actual crop yield for N-fixing crops *i* (t)
$Frac_{NCRBFi}$ : Amount of nitrogen per crop yield for N-fixing crops *i* (kgN/t)
$Frac_{NRESBFi}$ : Amount of nitrogen per crop residue for N-fixing crops *i* (kgN/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 we used 10% for the proportion of legume feed crops in mixed-sown in accordance with the judgments of experts based on a Japanese study[3] 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*

[3] 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 yieild and nutrient value" http://www.agri.pref.hokkaido.jp/center/kenkyuseika/gaiyosho/h12gaiyo/20003161.htm

*Guidelines* cover the plowdown amount of aboveground biomass residue and underground biomass, 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.

$$F_{BN} = \sum_i [Crop_{BF} \bullet Frac_{NCBGF}]$$

$F_{BN}$ : Amount of nitrogen fixed by leguminous feed crops (kgN)

$Crop_{BF}$ : Actual crop yield for leguminous feed crop (t)

$Frac_{NBGBFi}$ : Amount of nitrogen contained in the underground part per crop yield for leguminous feed crop (kgN/t)

Table 6-32 Parameters used in estimating for N-fixing crops

| Type of crop | Amount of fixed nitrogen per unit crop yield (kgN/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 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 GPG (2000). The uncertainties for activity data were determined to be 0.27% of standard error for the area of upland field indicated in the Statistics of Cultivated and Planted Area. As a result, the uncertainties for emission for 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 *Good Practice Guidance (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

Because the estimation was recommended by expert review team, this category is estimated since this report.

### *f) Source-specific Planned Improvements*

More detailed work is needed on the percentage of legume feed crops in mixed-sown pastures. Currently there are insufficient data on underground plowdown, which is needed for the transition to calculations conforming to those of the *2006 IPCC Guidelines*. For that reason this will be set aside as a matter for future consideration, along with improving the calculation method for plowdown.

## 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 application of crop residue.

### *b) Methodological Issues*

**●*Estimation Method***

Nitrous oxide 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 for soil amendment.

| |
|---|
| *Nitrous oxide emission associated with the use of crop residues for soil amendment (kgN$_2$O)* |
| = Default emission factor [kg-N$_2$O-N/kg-N] × Nitrogen input through the use of crop residues for soil amendment [kg-N] ×44/28 |

**●*Emission Factors***

The default emission factor, 0.0125 [kg-N$_2$O-N/kg-N], shown in the *Revised 1996 IPCC Guidelines* and the *Good Practice Guidelines (2000)* was used.

**●*Activity Data***

[Crops other than rye, (for grain), oats (for grain), Tea, Feed Crops, Maize and Sorgo]

The amount of nitrogen in crop residue plowed into soil was calculated by multiplying nitrogen content included in crop residue per crop yield (kgN/t) (which was basic unit using Japan's country-specific data of nutrient balance for each crop (Owa, 1996)) by annual crop yield by the percentage of crop residue less the percentage burned in the field (0.1, the default value in the *Revised 1996 IPCC Guidelines*)

Wherever any crop has no available data with respect to nitrogen content included in crop residue per crop yield, the value for a similar type of crop was used. Furthermore, the same values were adopted for all fiscal years. For crops cultivated for use as animal feed and fertilizers, the area used for fodder was excluded. On the assumption that field burning is not practiced in Japan, crops which were not included in the calculation for the Field Burning of Crop Residues (4.F) category were excluded from the multiplication by the "percentage less the percentage burned in field."

| |
|---|
| Amount of nitrogen in crop residue plowed into soil (kg-N) (other than rye, oats, tea, feed crops, maize and sorgo) |
| $= \Sigma_{crop}$ { Annual crop yield [t] × Nitrogen content included in crop residue per crop yield [kgN/t]× (1－Proportion burned in field)} |

| Data | Source |
|---|---|
| Nitrogen content of non-harvest aboveground portion by crop | Owa, *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 37) |
| Percentage burned in field | *Revised 1996 IPCC Guidelines* |
| Cultivated area of vegetables | *Vegetable Production and Shipment Statistics* (MAFF) |
| Cultivated area of crops other than vegetables | *Statistics of Cultivated and Planted Area* (MAFF) |

[Tea, Feed Crop, Maize and Sorgo]

With regard to tea there are plans to review the calculation for plowdown amount itself (see "f) Source-specific Planned Improvements" below), while with regard to pasture grass, corn silage, and sorgo, at present it is impossible to find the harvest amount that was used for plowdown with statistical information alone. Such being the case, the amount of nitrogen in crop residues plowed into the soil was estimated by multiplying the Japan-specific "amount of nitrogen in the aboveground, unharvested portion of crop plants" (kg N/10 a) by the area of land cultivated for each crop type. For corn silage that value was multiplied by the percentage left when subtracting the percentage burned in the field (the default value in the *Revised 1996 IPCC Guidelines*: 0.1).

Amount of nitrogen in crop residue plowed into soil (kg-N) *(Tea, Feed Crop, Maize and Sorgo)*

= $\sum_{crop}$ {Amount of nitrogen contained in aboveground unharvested portion per area [kgN/10 a] × Cultivated area [ha] × (1 – Percentage burned in field)} × 10

| Data | Source |
|---|---|
| Nitrogen content of non-harvest aboveground portion by crop | Owa, *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 37) |
| Percentage burned in field | *Revised 1996 IPCC Guidelines* |
| Cultivated area per crop | *Statistics of Cultivated and Planted Area* (MAFF) |

[Rye and Oats (for grain)]

In accordance with the default technique described in the *Revised 1996 IPCC Guidelines* and the *Good Practice Guide (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 the default value of 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.

*Nitrogen plowed into soil with crop residues (kg-N) (rye and oats)*

= 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 volumes 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 6-33 Planted area of rye and oats (for grain)

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Rye | ha | 50 | 119 | 110 | 120 | 140 | 130 | 150 |
| Oat | ha | 4,000 | 2,517 | 1,600 | 800 | 700 | 700 | 600 |

Source: The data are calculated by using the *Statistics of Cultivated and Planted Area* (MAFF)

Table 6-34 Yields of rye and oats per unit area

| Crop | Yield per unit area | Note |
|---|---|---|
| Rye | 424 [kg/10 a] | Data determined by specialists based on the results of rye cultivation tests in |
| Oats | 223 [kg/10 a] | Data available only up to FY 1994. The 1994 figures were used for all fiscal 994 since the data were available for major prefectures only for these years. |

Table 6-35 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 | 0.10 |
| Oats | 2.23 | 0.92 | 0.0070 | 0.10 |
| Source | Determined by specialists | *Good Practice Guidelines (2000)*, p. 4.58, Table 4.16 | | *Revised 1996 Guidelines,* Vol. 3, p. 4.83 |

### *c) Uncertainties and Time-series Consistency*

**●*Uncertainties***

Because the estimation methods for rye and oats differ from those for other crops, the uncertainties were calculated independently for rye and oats and for other crops. Finally, these uncertainties were combined as total uncertainty.

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 *Good Practice Guidance (2000)*. The uncertainties for emission factors for rye and oats were calculated to combine each parameter determined by expert judgment or standard values in the *Good Practice Guidance (2000)*, and were determined to be 388% for rye and 392% for oats.

The uncertainties for activity data were assessed as 0.34% for paddy rice and 0.27% for other crops by applying the standard errors in the *Statistics of Cultivated and Planted Area*.

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 *Good Practice Guidance (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*

Although for many crops, the nitrogen amount put in soil as crop residue was calculated by multiplying area by the nitrogen amount in harvest residue per area, the change of crop yield per area is not reflected in the estimation of emissions, and there is a tendency for the fixed yield of survey results used for the estimation to be slightly higher than the national average yield. Therefore, for the crops when its data are available, the estimation methods of nitrogen amount put in soils are changed to calculate by multiplying crop yield by nitrogen amount in harvest residue per crop yield. As a result, the recalculations of emissions in the past years were conducted.

Furthermore, in the agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### *f）Source-specific Planned Improvements*

It is needed to discuss whether it will be possible to establish country-specific emission factors for Japan.

It is possible that in the case of tea, the data for nitrogen amount in crop residue are not accurate, making it necessary to consider improvements to the calculation method.

## 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 (Nagata 2007), and in general farmers till land that has had soil dressing.

### *b）Methodological Issues*

●***Estimation Method***

Emissions of nitrous oxide 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 *Good Practice Guide (2000)*.

| |
|---|
| <u>*Nitrous oxide emission associated with the plowing of organic soil (kg-$N_2O$)*</u><br>= 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) 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 [kgN2 O-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 2007), but there is not much difference from the default of temperate region (8[kg$N_2$O-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.

Table 6-36 Percentage of organic soil

| | Percentage of organic soil | Data Source |
|---|---|---|
| Paddy fields | 6.4% | Average of values in the *Yearbook of Fertilizer Statistics* (Pocket edition; Association of Agricultural and Forestry Statistics) and the *Basic Survey of Ground Strength* (1959 – 1978; MAFF). |
| Common upland fields | 1.9% | |

Table 6-37 Areas of organic soil

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| Area of organic soil (paddy field) | ha | 182,144 | 175,680 | 169,024 | 163,584 | 162,752 | 161,920 | 161,024 |
| Area of organic soil (field) | ha | 24,225 | 23,275 | 22,572 | 22,287 | 22,287 | 22,268 | 22,249 |

### 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 *Good Practice Guidance (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, 0.14% of the standard error for paddy rice and 0.27% 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 *Good Practice Guidance (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

With regard to the tillage of organic soil (rice paddies), it was noted that the default emission factor is possibly too large for Japan's situation, and because it was possible to set an emission factor based on cases observed in Japan, a change was made from the default value to a country-specific one. As a result, emissions for all years were updated.

Additionally, because the agriculture sector uses three-year averages, FY2006 emission are recalculated by FY2007 revisions and updates of activity data.

### *f） Source-specific Planned Improvements*

Although the country-specific emission factor for paddy field is used for this report, in order to avoid double counting of N2O emission, issues to be addressed remain; one of them is the exclusion of the influence of the stubble, which remains in the ground surface after harvest, and of the insertion of crop residue in soil such as straw, is not performed. It is necessary to advance further detailed checking so that the more suitable national condition can be reflected to the emission factor, including upland field which use default emission factor..

In order to establish more suitable emission factors based on actual measurements including the one for upland filed for which the default value is currently used, further review will be necessary.

Since the area of organic soil used as agricultural land in Japan has been improved by land improvement projects, such as the drainage and soil dressing, it is most unlikely that organic matter is contained in the plow layer. Therefore, there is a possibility that the emissions are overestimated. Therefore, it is necessary to obtain the data of the organic soil area (percentage) where ploughing is actually carried out by performing the survey of ploughing of an organic soil, and to develop suitable activity data based on it (inter alia, in Hokkaido where organic soils exist widely).

#### 6.5.1.6. Direct Emissions ($CH_4$)

Methane-generating bacteria are absolutely anaerobic, and if soil is not maintained in an anaerobic state, methane 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 methane 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***

Nitrous oxide emissions associated with atmospheric deposition have been calculated using default emission factors, in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 4.69, Fig. 4.8).

| <u>*Calculation of nitrous oxide emissions associated with atmospheric deposition*</u> |
|---|
| Emissions of nitrous oxide from atmospheric deposition [kg $N_2O$]<br>＝ Default emission factor [kg $N_2O$-N/kg $NH_3$-N+$NO_X$-N]<br>× Volume 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 6-38 Emission factor for nitrous oxide emissions associated with atmospheric deposition

| | Emission Factor [kg$N_2O$-N/kg $NH_3$-N & $NO_X$-N deposited] |
|---|---|
| Nitrous oxide emissions associated with atmospheric deposition | 0.01 |

Source: *Revised 1996 IPCC Guidelines* Vol.2 Table 4-18 (*Good Practice Guidance (2000)* Table4.18) (Reference 3)

●***Activity Data***

The amounts of nitrogen (kg) contained in ammonia and nitrogen oxides that volatilize from synthetic fertilizers applied to agricultural soil and livestock manure were calculated for activity data. For the amount of manure-derived nitrogen applied to agricultural soil, the portion of nitrogen content in the livestock manure in Japan which was returned to agricultural soil, calculated in the *4.B. Manure Management* section, was used to maintain consistency in the nitrogen cycle. Also, the portion of human waste which was returned to agricultural soil as fertilizer was added to the activity data reported in this section.

$$A = N_{FERT} * Frac_{GASF} + N_{ANI}$$
$$= N_{FERT} * Frac_{GASF} + N_B * Frac_{GASM1} + (N_D + N_{FU}) * Frac_{GASM2}$$

| | |
|---|---|
| A: | 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) |
| $N_{FERT}$: | Demand for synthetic nitrogen fertilizers (kg-N) |
| $Frac_{GASF}$: | Percentage of volatilization as ammonia and nitrogen oxides from synthetic fertilizers (kg-$NH_3$-N + $NO_X$-N/kg-N) |
| $N_{ANI}$: | Amount of nitrogen that volatilizes as ammonia and nitrogen oxides from livestock manure and human waste (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/kgN) |
| $N_D$: | Amount of manure-derived fertilizer applied to agricultural soil (kg-N) |
| $N_{FU}$: | Amount of human waste-derived fertilizer 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) |

➢ ***Synthetic Fertilizers***

Activity data for nitrous oxide emissions associated with atmospheric deposition in the application of synthetic fertilizers was derived by multiplying "demand for nitrogen-based fertilizers" given in the Ministry of Agriculture, Forestry and Fisheries *Yearbook of Fertilizer Statistics (Pocket Edition)* by the default value of $Frac_{GASF}$, the proportion of nitrogen volatilized as ammonia or nitrogen oxides from synthetic fertilizers, given in the *Revised 1996 IPCC Guidelines*.

Table 6-39 $Frac_{GASF}$: Proportion of nitrogen volatilized as ammonia or nitrogen oxides from synthetic fertilizers

| Value | Unit |
|---|---|
| 0.1 | [kg $NH_3$-N + $NO_X$-N/kg of synthetic fertilizer nitrogen applied] |

Source: *Revised 1996 IPCC Guidelines* Vol.2 Table 4-17

➢ ***Livestock manure and human waste***

Activity data for nitrous oxide emissions associated with atmospheric deposition occurred by livestock manure applied to farmland was calculated by multiplying the values determined in the *Manure Management (4.B.)* section (excluding the amount dispersed in the atmosphere as nitrous oxide as well as the amount treated by the "Incineration" or "Purification" in the *Manure Management (4.B.)* less the portion not applied to agricultural soils as fertilizer) by the default value for the "$Frac_{GASM}$: fraction of livestock nitrogen excretion that volatilizes as $NH_3$ and $NO_X$ (Table 6-15).

The activity data derived by human waste was defined by the product of the amount of human waste-derived nitrogen calculated with *Waste Treatment in Japan* and $Frac_{GASM}$.

The amount of nitrogen that eventually converted to $NH_3$ and $NO_2$ and volatilized in the process of treating livestock manure was defined by the product of the amount of manure excreted by cattle in a shed and barn and by pastured cattle, and the figures indicated in Table 6-14.

Table 6-40 $Frac_{GASM}$: Proportion of nitrogen volatilized from livestock manure as ammonia or nitrogen oxides

| Value | Unit |
|---|---|
| 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)

Table 6-41 Nitrogen returned to agricultural soil

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|
| N applied to agriclutural soil from livestock waste | tN | 542,025 | 519,419 | 492,296 | 471,588 | 477,043 | 471,958 | 470,594 |
| N applied to agriclutural soil from human waste | tN | 10,394 | 4,747 | 2,116 | 874 | 729 | 731 | 729 |

### 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 *Good Practice Guidance (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 *Good Practice Guidance (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*

Responding to the change of basic unit of manure for cattle, swine and poultry and change of activity data for sheep, goats and horses, emissions for this category from FY1990 to FY2006 were recalculated.

#### *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***

Nitrous oxide emissions associated with leaching and run-off of nitrogen were calculated according to the Decision Tree in the *Good Practice Guide (2000)* (Page 4.69, Fig. 4.8), by multiplying Japan's country-specific emission factors by the amount of nitrogen that leached or ran off.

> <u>*Nitrous oxide emission associated with nitrogen that leached or ran off (kg-$N_2O$)*</u>
> = Emission factor associated with nitrogen leaching and runoff [kg-$N_2O$-N/kg-N] × Nitrogen that leached or ran off [kg-N] × 44/28

● ***Emission Factors***

The nitrous oxide emission from this source was calculated using the Japan-specific emission factor that had been established by various studies. The same value was used for the nitrous oxide emission factor for nitrogen leaching and run-off for all of the fiscal years covered in the report.

Table 6-42 Emission factor for $N_2O$ emissions associated with nitrogen leaching and run-off

| | Emission factor [kg-$N_2O$-N/kg-N] |
|---|---|
| Nitrous oxide 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 derived by multiplying the proportion of applied nitrogen subject to leaching and run-off, as 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 6-43 $Frac_{LEACH}$: Proportion of nitrogen applied subject to leaching and run-off

| Value | Unit |
|---|---|
| 0.3 | [kg N/kg nitrogen 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 l 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 *Good Practice Guidance (2000)*. The aggregated uncertainty for emission factor was determined to be 113% for synthetic fertilizers and livestock manure in common. 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 *Good Practice Guidance (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*

Responding to the change of basic unit of manure for cattle, swine and poultry and change of activity data for sheep, goats and horses, emissions for this category from FY1990 to FY2006 were recalculated.

### f） *Source-specific Planned Improvements*

Refer to 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", same as.

Except for atmospheric deposition or nitrogen leaching and run-off, there is no conceivable source of methane emissions from cultivated farmland soil other than direct emissions from soil, animal production, and indirect emissions. Therefore, they have therefore been reported as “NO”.

### 6.5.4. Other (4.D.4)

Because it is not likely that agricultural sources of methane and nitrous oxide 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 *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 methane and nitrous oxide into the atmosphere. Methane and nitrous oxide emissions from this source are calculated and reported in this category.

$CH_4$ and $N_2O$ emissions from Field Burning of Agricultural Residues in FY 2007 are 103Gg-$CO_2$ and 76Gg-$CO_2$, comprising 0.01% and 0.01% of total emissions, respectively. The value represents a reduction by 20.7% and 26.6% for $CH_4$ and $N_2O$ from FY 1990, respectively.

### 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***

Methane and nitrous oxide emissions from field burning of crop residues of rice, wheat, barley, rye, and oats were calculated, using the default technique indicated in the *Revised 1996 IPCC Guidelines* and the *Good Practice Guide (2000)*, by multiplying the amounts of carbon and nitrogen released by field burning by the methane emission rate and nitrous oxide emission rate, 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.

*Methane emission associated with field burning of agricultural residues(kg$CH_4$)*
= Methane emission rate (kg $CH_4$-C/kgC) × Total carbon released(kgC) × 16/12

*Nitrous oxide emission associated with field burning of agricultural residues(kg$N_2O$)*
= Nitrous oxide emission rate (kg $N_2O$-N/kgN) × total nitrogen released(kgN) × 44/28

●***Emission Factors***

The default values shown in the Revised 1996 IPCC Guidelines and the Good Practice Guide (2000) were used.

Table 6-44 Emission factors for methane and nitrous oxide emissions associated with field burning of rice, wheat, barley residues, rye, and oats

| | 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***

Activity data was calculated in accordance with the default technique shown in the *Revised 1996 IPCC Guidelines* and the *Good Practice Guide (2000)*, using the following formula:

*Total carbon/total nitrogen released by field burning of agricultural residues(kgC, kgN)*
= 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(tC/t-dm, tN/t-dm) × $10^3$

➢ ***Annual crop yield***

[Rice, wheat (grain), and barley (grain)]

The values reported in the *Crop Statistics* were used for the yield of rice, 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).

- ***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 and proportionally divided by the yield of wheat and barley (grain).

Table 6-45 Yield of rye and oats per unit area

| Crop | Yield per unit area | Data Source |
|---|---|---|
| Rye | 424 | Determined by specialists (based on rye crop tests in Japan) |
| Oats | 223 | MAFF, *Crop Statistics* |
| Rye and Oats (for green crops) | 1,100 | Determined by specialists (based on literature) |

Proportions of residues to crop yield and dry matter in residue, carbon content, proportion burned in field, and oxidation rate.

Table 6-46 shows the parameters for each crop.

Table 6-46 Proportions of residue to crop yield and dry matter in residue, carbon content, proportion burned in field, and oxidation rate

| Crop | Proportion of residue[a)] | Proportion of dry matter in residue[a)] | Carbon content[a)] | Nitrogen content | Proportion burned in field[b)] | Oxidation rate[b)] |
|---|---|---|---|---|---|---|
| Rice | 1.4 | 0.85 | 0.4144 | 0.0068[h] | 0.10 | 0.90 |
| Wheat (grain) | 1.3 | 0.85 | 0.4853 | 0.0045 [h] | 0.10 | 0.90 |
| Barley (grain) | 1.2 | 0.85 | 0.4567 | 0.016 [g,h] | 0.10 | 0.90 |
| Wheat/barley (green crop) | --- | 0.17[c)] | 0.48[d)] | 0.016 [g] | 0.10 | 0.90 |
| Rye | 2.84[e)] | 0.90[c)] | 0.4710[f)] | 0.0048 | 0.10 | 0.90 |
| Oats | 2.23[e)] | 0.92[c)] | 0.4710[f)] | 0.007 | 0.10 | 0.90 |
| Rye (green crop) | --- | 0.17[c)] | 0.4710[f)] | 0.0116 | 0.10 | 0.90 |
| Oats (green crop) | --- | 0.17[c)] | 0.4710[f)] | 0.0169 [h] | 0.10 | 0.90 |

a) *Good Practice Guide (2000)*, p. 4.58, Table 4.16 (Reference 4)

b) *Revised 1996 IPCC Guidelines,* Vol. 3, p. 4.83 (Reference 3)

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 *Good Practice Guide (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 Guide (2000).*

g) Values change over the years

h) Owa, *New Trends in Technology for Efficient Use of Nutrients – Nutritional Balance of Crops in Japan* (1996) (Reference 37)

➢ ***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 *Good Practice Guide (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)”. For other wheat (grain), the value shown in *Revised 1996 IPCC Guidelines* was used.

### *c) Uncertainties and Time-series Consistency*

●***Uncertainties***

The uncertainty assessment was conducted by each crop for rice, wheat (grain), barley (grain), wheat/barley(green crop), rye, oats, rye (green crop), and oats (green crop). The uncertainties for emission factors were calculated to combine the uncertainty of each parameter determined by expert judgment or given in the *Good Practice Guidance (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 *Good Practice Guidance (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 agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### f） *Source-specific Planned Improvements*

For the use of the default parameter in the *Revised 1996 IPCC Guidelines* or the *Good Practice Guidance (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, Sugarbeet & 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 & Sugar cane.

### b） *Methodological Issues*

●***Estimation Method***

Methane and nitrous oxide emissions from field burning of crop residues of corn, peas, soy, adzuki beans, kidney beans, peanuts, potatoes and other root crops (sugarbeets), and sugar cane were calculated in accordance with the relevant Decision Tree in the *Good Practice Guide (2000)* (page 4.52, Fig. 4.6), by multiplying the total carbon released, as calculated by the default technique, by the default methane emission rate and nitrous oxide emission rate, respectively.

●***Emission Factors***

Emission factors similar to field burning of rice, wheat, and barley residues were used (See Table 6-44).

●***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 calculation formula.

Table 6-47 Proportions of residues, dry matter, carbon, and nitrogen relative to crop yield

| Crop | Proportion of residues | Proportion of dry matter | Carbon content | Nitrogen content[b] |
|---|---|---|---|---|
| Corn | 1.0 | 0.86 | 0.4709 | 0.0164 |
| Peas | 1.5 | 0.87 | 0.45[a] | 0.0159 |
| Soy | 2.1 | 0.89 | 0.45[a] | 0.0065 |
| Adzuki beans | 2.1 | 0.89 | 0.45[a] | 0.0084 |
| Kidney beans | 2.1 | 0.89 | 0.45[a] | 0.00745 |
| Peanuts | 1.0 | 0.86 | 0.45[a] | 0.00745 |
| Potatoes | 0.4 | 0.6[c] | 0.4226 | 0.0242 |
| Sugarbeets | 0.2 | 0.2 | 0.4072 | 0.0192 |
| Sugar cane | 1.62 | 0.83[c] | 0.4235 | 0.0423 |

Source: *Good Practice Guide (2000)*, p. 4.58, Table 4.16 (Reference 4)

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 37)

c: *Revised 1996 IPCC Guidelines*, Vol. 2, Table 4-15

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.

Table 6-48 Default values of proportion burned in field and oxidation rate

| | Value | Unit |
|---|---|---|
| Proportion burned in field | 0.10 | - |
| Oxidation rate | 0.90 | - |

Source: *Revised 1996 IPCC Guidelines*, Vol. 3, p. 4.83 (Reference 3)

### c） Uncertainties and Time-series Consistency

**●*Uncertainties***

The uncertainty assessment was conducted by each crop in Peas, Soybeans, Adzuki beans, Kidney beans, Peanuts, Potatoes, Sugarbeet.

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 Good Practice Guidance (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 agricultural sector, a 3-year average has been used. Thus, cause of revision and update of the activity data for FY 2007, the emissions for FY 2006 were revised accordingly.

### f） Source-specific Planned Improvements

For the use of the default parameter in the *Revised 1996 IPCC Guidelines* or the *Good Practice Guidance (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 waste 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 sector5)

## 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 6 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 enforced within 20 years, in accordance with GPG-LULUCF. GHG emission and removal estimates in this sector are calculated from carbon stock changes in the five carbon pools (aboveground biomass, belowground biomass, deadwood, 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. For this inventory, above- and belowground biomass are referred to collectively as "living biomass", and deadwood and litter collectively as "dead organic matter".

Japan's total land area as of FY 2007 is about 37.8 million ha, and about 76.8% of the land consists of Forest land and Cropland. Forest land covers about 25.0 million ha. The second-largest portion is Cropland, which covers about 4.0 million ha. In addition, Grassland, Wetlands, Settlements, and Other land cover about 0.91 million ha, 1.33 million ha, 3.68 million ha, and 2.86 million ha, respectively.

Most of Japan's national land is located in a temperate, humid climate. The average annual temperature of the capital city, Tokyo, is 15.9 centigrade, and the average annual precipitation is 1,470 mm.[1]

The LULUCF sector contains both sources and sinks; however, in Japan, it has been a net sink continuously since FY 1990. Net removals in FY 2007 were 81,353 Gg-$CO_2$; this accounts for 5.9% of the total national emissions. The net removals in FY 2007 also represent an increase of 9.5% over the FY 1990 value and a decrease of 0.5% over the FY 2006 value.

This chapter is divided into 13 sections. Section 7.2 describes a method of determining land-use categories. Sections 7.3 to 7.8 explain carbon stock changes in each land-use category. Non-$CO_2$ GHGs associated with the LULUCF sector are described in sections 7.9 to 7.13.

## 7.2. Method of determining land use categories

### 7.2.1. Basic approach

In accordance with Approach 1, land is classified according to the definitions in existing statistics. Subcategories are determined independently for Forest land and Cropland (Forest land: Forest with standing trees (intensively managed forests / semi-natural forests) / Forests without standing

[1] These values are mean ones between FY 1971 and 2000. See National Astronomical Observatory, *2008 Chronological Scientific Tables* (Tokyo: Maruzen Inc., 2007) p.176 and p.188.

trees / bamboo; Cropland: rice fields / upland fields / orchard).

“Land remaining Land” and “Land converted to Land” in each land use category are determined from existing statistics. When partial areas cannot be directly determined from statistics, these are estimated proportionately or by other means.

The area of Other land which does not belong to any of the other five land use categories, is determined by taking the difference between the total area of national land and the total area belonging to the five land use categories.

### 7.2.2. Method of determining land use categories and areas

Table 7-1 shows the method of determining land use categories and areas in Japan by means of existing statistics.

Table 7-1 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. | Forest with standing trees (intensively managed forests, semi-natural forests), forests without standing trees and bamboo* in the forests which are included in the regional forests plan according to *Forestry Status Survey* [-2004] and *National Forest Resources Database* [2005-] (Forestry Agency) |
| Cropland | Rice fields, upland fields and orchard. | Rice fields, upland fields and orchard according to *Statistics of Cultivated and Planted Area* by the Ministry of Agriculture, Forestry and Fisheries. |
| Grassland | Pasture land, grazed meadow land and grassland other than pasture land and grazed meadow land[2]. | Pasture land according to *Statistics of Cultivated and Planted Area* by the Ministry of Agriculture, Forestry and Fisheries, grazed meadow land according to *World Census of Agriculture and Forestry*, also by the Ministry of Agriculture, Forestry and Fisheries and less-managed grassland other than pasture land and grazed meadow land identified in *Land Use Status Survey*. |
| Wetlands | Bodies of water (such as dams), rivers, and waterways. | Bodies of water, rivers, and waterways according to *Land Use Status Survey, Survey of Forestry regions*, also by the Ministry of Land, Infrastructure, Transport and Tourism. |
| 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* by the Ministry of Land, Infrastructure, Transport and Tourism. The included figures for urban green areas are taken from *Urban Parks Status Survey*, *Road Tree Planting Status Survey, Sewage Treatment Facility Status Survey, Urban Greening Status Survey, Survey on Carbon Dioxide Absorption at Source in River Works, Progress Survey on Tree Planting for Public Rental Housing,* also by the Ministry of Land, Infrastructure, Transport and Tourism. |

[2] Grassland other than pasture land and grazed meadow land is the land that remains after subtracting grazed meadow land and jurisdictional areas as national forests 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).

Table 7-1 Method of determining land use categories and areas (continue)

| Land use category | Method of determining land use category | Method of determining area |
|---|---|---|
| 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 *Land Use Status Survey* by the Ministry of Land, Infrastructure, Transport and Tourism. |

Note: Forest with standing trees (intensively managed forests, semi-natural forests), forest without standing trees and bamboo are defined as below.

<table>
<tr><td rowspan="2">Forest with standing trees:<br>Forest that has tree crown cover 30 percent or higher (including young stands)</td><td>Intensively managed forests:<br>Forest land that is subject to artificial regeneration such as tree planting and seeding, and no less than 50% of tree species in the land are subject to artificial regeneration</td></tr>
<tr><td>Semi-natural forests:<br>Forest with standing trees which is not classified as intensively managed forests</td></tr>
<tr><td colspan="2">Forest without standing trees (Forests without standing trees):<br>Forest that does not fall under “forest with standing trees” and “bamboo”</td></tr>
<tr><td colspan="2">Bamboo:<br>Forest that does not fall under “forest with standing trees” and is dominated by bamboo (excluding bamboo grass)</td></tr>
</table>

### 7.2.3. Survey method and due date of major land area statistics

Survey method and due date of major land area statistics are as below;

Table 7-2 Survey method and due date 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 | Ministry of Agriculture, Forestry and Fisheries, (Forestry Agency) |
| *National Forest Resources Database* | Complete count survey | April, 1st | Every year | Ministry of Agriculture, Forestry and Fisheries (Forestry Agency) |
| *Statistics of Cultivated and Planted Area (Survey of cropland area)* | Cropland area: Ground measurement survey (sample) Conversion area: Tabular survey (using documents from relevant agency and aerial photograph, etc.) | Cropland area: - July, 15th expansion area and converted area of cropland - July, 15th in the previous year - July, 14th | Every year | Ministry of Agriculture, Forestry and Fisheries |

Table 7-2 Survey method and due date of major land area statistics (continue)

| Name of the statistics / census | Survey method | Survey due date | Frequency | Presiding ministry |
|---|---|---|---|---|
| *World Census of Agriculture and Forestry (Survey Of Forestry Regions~2000)* | Complete count survey | August, 1st | Every 10 years | Ministry of Agriculture, Forestry and Fisheries |
| *Land Use Status Survey* | Complete count Survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |
| *Urban Parks Status Survey* | Complete count survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |
| *Road Tree Planting Status Survey* | Complete count survey | March, 31st | 5 years for the period from FY 1987 to FY 2007, and every year since FY 2008 | Ministry of Land, Infrastructure, Transport and Tourism |
| *Sewage Treatment Facility Status Survey* | Complete count survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |
| *Urban Greening Status Survey* | Complete count survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |
| *Survey on Carbon Dioxide Absorption at Source in River Works* | Complete count survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |
| *Progress Survey on Tree Planting for Public Rental Housing* | Complete count survey | March, 31st | Every year | Ministry of Land, Infrastructure, Transport and Tourism |

### 7.2.4. Land area estimation

Some land area were estimated proportionally or by other means because these area can not be directly determined from existing statistic information in Japan. For the estimation of land area, Japan used following methods;

- Interpolation and trend extrapolation
- Using the ratio of actual land area for each land use categories
- Using the ratio of converted land area for a certain year

- ***Interpolation and trend extrapolation***

➢ ***Method***

The Forest land area data before 2004 was based on periodic measurements which were conducted approximately 5 year intervals. Therefore, it is necessary to fill the data of un-measured years. In such cases, un-measured Forest land area data were linearly interpolated or extrapolated by measurement data.

➢ ***Land use category***

5.A. Forest land remaining Forest land (FY 1991-FY 1994, FY 1996-FY 2001 and FY 2003-FY 2004)

● ***Using the ratio of actual land area for each land use categories***

➢ ***Method***

In Japan, areas of "upland field converted to Forest land", "orchard converted to Forest land" and "pasture converted to Forest land" are not available. Therefore, each land area was estimated by multiplying total converted land area (= upland field converted to Forest land + orchard converted to Forest land + pasture converted to Forest land, which total land area is available) by the ratio of actual land area for each land use categories under the assumption that the ratio of converted land area is similar to the ratio of actual land area.

➢ ***Land use category***

5.A.2. Land (Cropland and Grassland) converted to Forest land
5.B.1. Cropland remaining Cropland
5.B.2. Land (Forest land, Grassland, Wetlands and Other land) converted to Cropland
5.C.1. Grassland remaining Grassland
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

● ***Using the ratio of converted land area for a certain year***

➢ ***Method***

In Japan, annual land area of "Settlements converted to Wetlands" is not available. Therefore, these land areas were estimated by multiplying area of "Land converted to Wetlands" (which data is available) by the ratio of "Settlements converted to Wetlands" (= "Settlements converted to Wetlands" / "Land converted to Wetlands") in FY 1998 under the assumption that the ratio is constant in time series.

➢ ***Land use category***

5.D.2. Land (Cropland, Grassland, Settlements and Other land) converted to Wetlands

## 7.3. Forest land (5.A.)

Forests absorb $CO_2$ from the atmosphere by photosynthesis; they fix carbon as organic substances and store these substances for a given period. In contrast, events such as logging and natural disturbances can possibly make forests a source of $CO_2$.

In FY 2007, Japan's forest land area was about 25.0 million ha—about 66.1% of the total national land area. The net $CO_2$ removal by this category in FY 2007 was 82,867 Gg-$CO_2$ (excluding 2.1 Gg-$CO_2$ of $CH_4$ and $N_2O$ emissions resulting from biomass burning); this represents an increase of 2.6% over the FY 1990 value, and a decrease of 0.6% over the FY 2006 value.

This section divides forest land into two subcategories, "Forest land remaining Forest land (5.A.1.)

and "Land converted to Forest land (5.A.2.)", and describes them separately in the following subsections.

### 7.3.1. 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 is defined as land that has remained forested without conversion for 20 years as of FY 2007. The net removal by this subcategory in FY 2007 was 81,595 Gg-$CO_2$ (excluding 2.1 Gg-$CO_2$ of $CH_4$ and $N_2O$ emissions resulting from biomass burning); this represents an increase of 8.6% over the FY 1990 value and a decrease of 0.4% over the FY 2006 value.

#### b) *Methodological Issues*

#### 1) *Carbon stock change in Living Biomass*

● ***Estimation Method***

In accordance with the decision tree provided in the GPG-LULUCF, carbon stock changes in living biomass in Forest land remaining Forest land are estimated by Tier 2 stock change method. In this method, a biomass stock change is the difference between the absolute amount biomass at two points in times.

$$\Delta C_{LB} = \sum_k \left\{ (C_{t2} - C_{t1}) / (t_2 - t_1) \right\}_k$$

$\Delta C_{LB}$ : annual change in carbon stocks in living biomass (tC/yr)
$t_1, t_2$ : time points of carbon stock measurement
$C_{t2}$ : total carbon in biomass calculated at time $t_2$ (tC)
$C_{t1}$ : total carbon in biomass calculated at time $t_1$ (tC)
k : type of forest management

The carbon stock in living biomass is calculated from the volume multiplied by wood density, biomass expansion factor, root-to-shoot ratio and carbon fraction of dry matter. These parameters except carbon fraction of dry matter are determined separately for tree species.

$$C = \sum_j \left\{ [V_j \cdot D_j \cdot BEF_j] \cdot (1 + R_j) \cdot CF \right\}$$

*C* : carbon stock in living biomass (t-C)
*V* : merchantable volume ($m^3$)
*D* : wood density (t-dm/$m^3$)
*BEF* : biomass expansion factor for conversion of merchantable volume
*R* : root-to-shoot ratio
*CF* : carbon fraction of dry matter ( t-C/t-dm)
*j* : tree species

● ***Parameters***

➢ ***Volume***

To estimate GHG emissions/removals from forest, Forestry Agency has developed the National Forest Resources Database (NFRDB) that makes a database of "Forest Registers" information (area, tree species, age, etc.).

With respect to the volume of Japanese cedar, Hinoki cypress and Japanese larch which are major tree species of intensively managed forests, Japan surveyed the consistency between site data and existing yield tables in private forest in FY 2003-2005 and identified systematic errors. Therefore, it prepared new yield tables and calculated the volume by applying the new yield tables of each region and tree type to forest areas of each tree type and age class stored in the Forest Status Survey or to the areas of each tree type and forest age stored in the NFRDB.

$$V = \sum_{m,j} (A_{m,j} \cdot v)$$

$V$ : 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 7-3 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>

- ***Yield tables developed by prefectures or Regional Forest Offices, and Forest Register***

When private forests or national forests establish forest planning (all forest lands are divided into 158 planning areas, and regional forest planning is established by 1/5 [about 30 planning areas] each year), field surveys are implemented in these forests to develop Forest Register which includes data on area, age, volume by tree species and so on.

When forest planning is established (private forests: each prefecture, national forests: Regional Forest Offices of National Forests), Forest Register is updated to reflect change in volume due to growth, cutting and disturbances.

In general, volume data described in the Forest Register is estimated based on land area data and yield tables which provide stand growth including effects of typical practices implemented for each regions, tree species and site classes (yield tables show relationship between stand age or age class and volume per area).

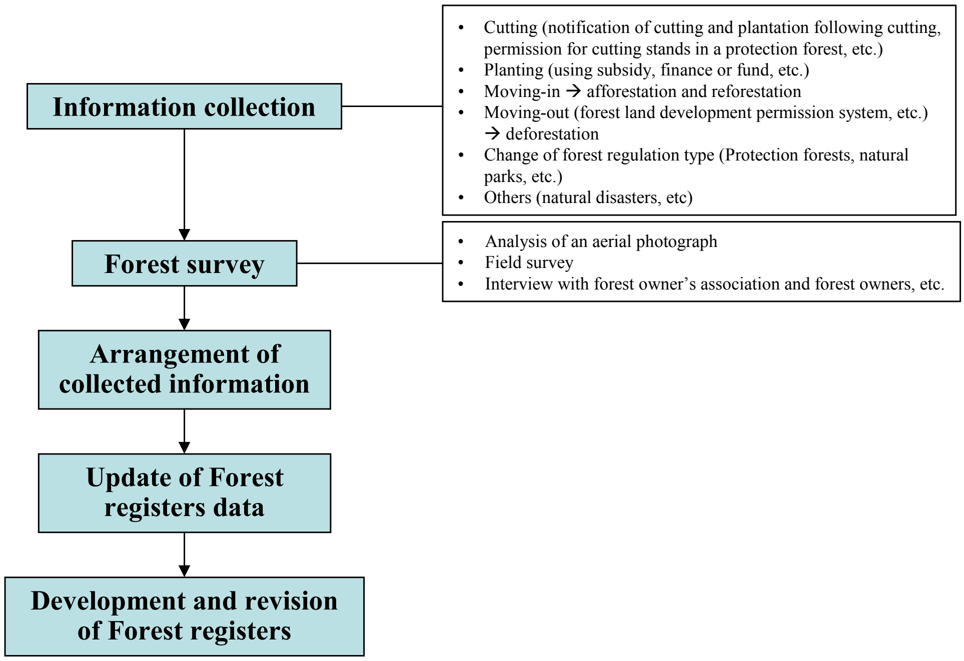


Figure 7-1 Procedures of Forest register development

- ***New Yield Tables(Japanese cedar, Hinoki cypress, Japanese larch)***

In 2006, Forestry and Forest Products Research Institute (FFPRI) developed new yield tables for Japanese cedar, Hinoki cypress and Japanese larch based on the results from field survey over the country. Area for these three tree types cover 82% of intensively managed forests in private forests.

The new yield tables for Japanese cedar were established for 7 regions, Hinoki cypress for 4 regions and Japanese larch for 2 regions.

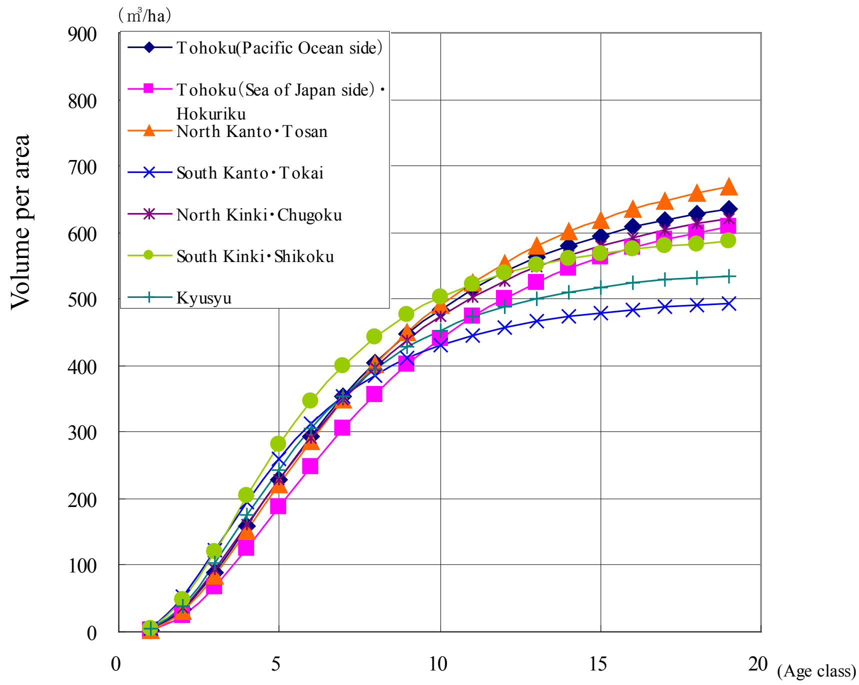


Figure 7-2 Yield tables made by forest resources monitoring survey data (Japanese cedar：7 areas)

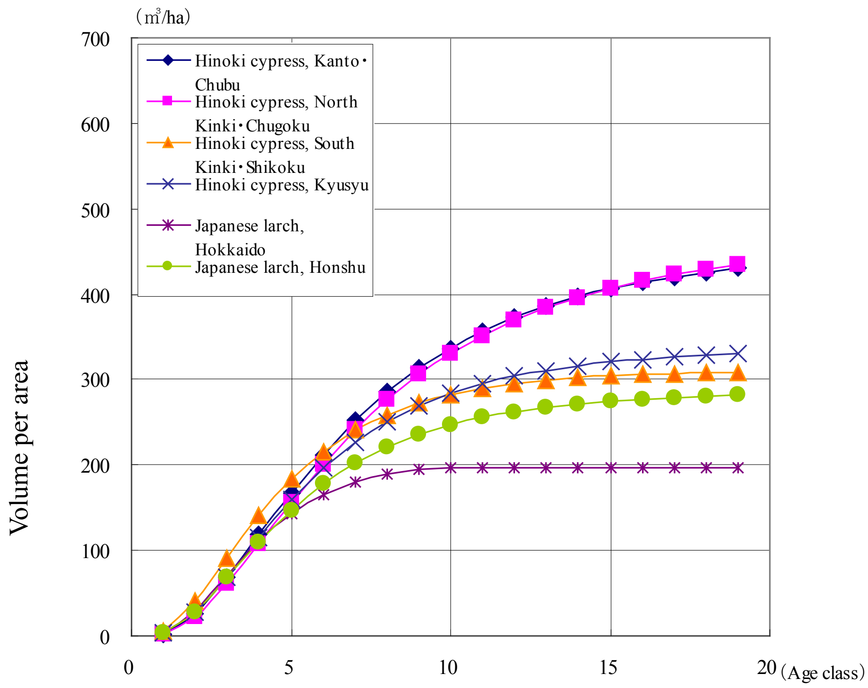


Figure 7-3 Yield tables made by forest resources monitoring survey data
(Hinoki cypress : 4 areas, Japanese larch : 2 areas)

- ***Biomass expansion factor and Root-to-shoot ratio***

Biomass expansion factor (BEF) and root-to-shoot ratio were updated based on the results from biomass survey on dominant tree species and existing research reports which were implemented by Forestry and Forest Products Research Institute.

BEFs were calculated for two age classes (20 years and below / 21 years and above), because it was identified that BEFs differ between young forests and mature forests.

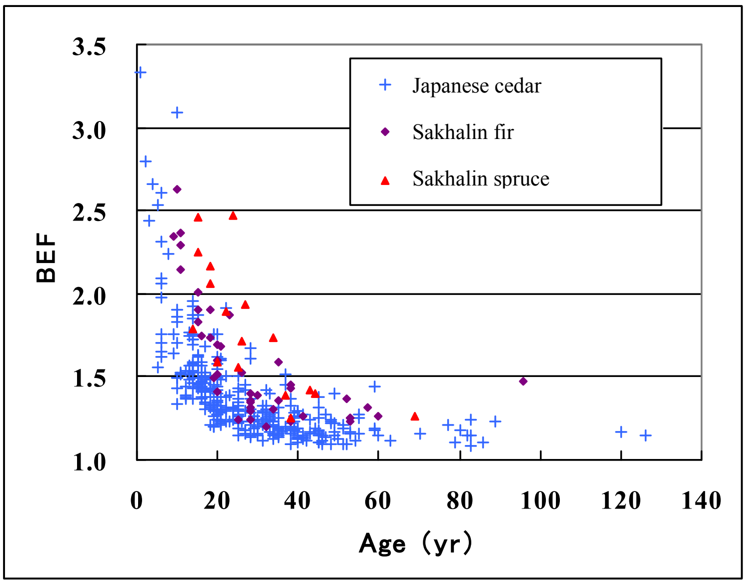


Figure 7-4 Biomass expansion factor related with age

These Root-to-shoot ratio values were established for each tree types, because root-to-shoot ratio was not correlated with age.

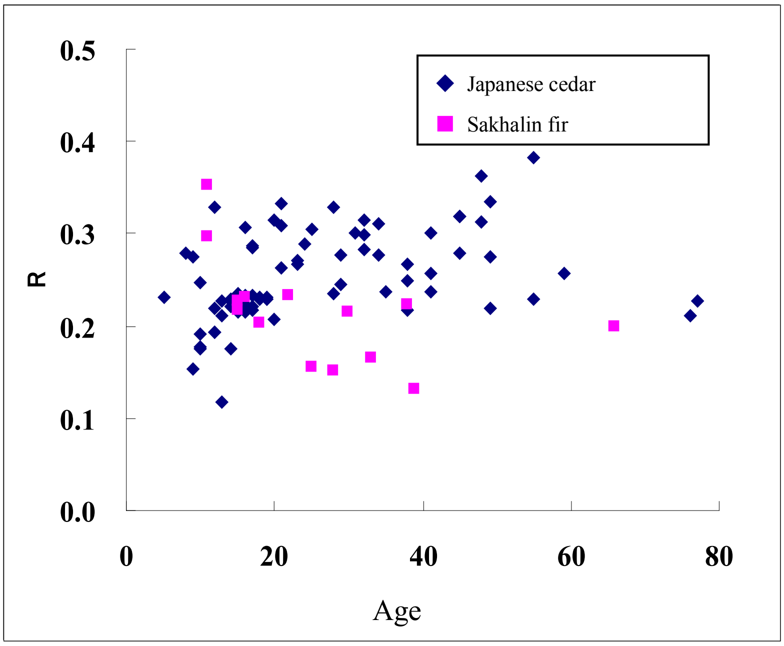


Figure 7-5 Aboveground biomass/belowground biomass(R), tree species, age

In addition, some biomass expansion factors and root-to-shoot ratios are updated based on newly obtained data. For further information, see Table 7-4.

➢ ***Wood density***

Wood density (D) data were updated based on the results from biomass survey on dominant tree species and existing research reports which were implemented by Forestry and Forest Products Research Institute. In addition, some wood densities are updated based on newly obtained data. For further information, see Table 7-4.

These D values were established for each tree types, because wood density was not correlated with age.

➢ ***Carbon fraction of dry matter***

The default value given in the GPG-LULUCF has been adopted as the carbon fraction of dry matter.

Table 7-4 BEF, Root-Shoot ratio, wood density for tree species provided in Forest register

| | | BEF | | R | D | CF | Note |
|---|---|---|---|---|---|---|---|
| | | ≦20 | ＞20 | | | | |
| 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, Tohoku, Tochigi, Gunma, Saitama, Niigata, Toyama, Yamanashi, Nagano, Gifu, Shizuoka |
| | | 1.39 | 1.36 | 0.34 | 0.464 | | Applied to Okinawa |
| | | 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 |
| | | 1.52 | 1.33 | 0.26 | 0.646 | | Applied to Mie, Wakayama, Oita, Kumamoto, Miyazaki, and |
| | | 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***

Activity data is calculated by summing planted forest area provided in "Forest Status Survey" and "National Forest Resource Database" (Forestry Agency) which include intensively managed forests, semi-natural forests, forests without standing trees and bamboo.

When forest area data are not available (e.g. FY 1991 - FY 1994), data for these years are interpolated based on available data.

➢ ***Determining the total forest area***

Forest area is the sum of intensively managed forests, semi-natural forests, forest without standing trees and bamboo under the forest planning system from the “Forest Status Survey” and National Forest Resource Database (Forestry Agency). Data for FY 1991 through FY 1994, FY 1996 through FY 2001, and FY 2003 through FY 2004 are estimated by interpolation. In addition, there are no area data of Sakhalin fir, Yezo spruce, Quercus autissima and Japanese Oaks before FY 1990. Note, however, that these area data are estimated from “other conifer” and “other broad leaf” area divided by area ratio in FY 1995.

Table 7-5 Classifications in *Survey on Status Forest Resources* and *National Forest resource Database*

| Conifer trees | | Broad leaf trees | |
|---|---|---|---|
| Before 2004 | After 2005 | Before 2004 | After 2005 |
| Japanese cedar | Japanese cedar | Japanese chestnut oak | Japanese chestnut oak |
| Hinoki cypress | Hinoki cypress | Oak (deciduous tree ) | Oak (deciduous tree ) |
| Pine | Japanese red pine | Other broad leaf | Japanese beech |
| | Japanese black pine | | Oak (evergreen tree) |
| Japanese larch | Japanese larch | | Japanese chestnut |
| Sakhalin fir | Sakhalin fir | | Japanese popular |
| Yezo spruce | Yezo spruce | | Alder |
| | Sakhalin spruce | | Japanese elm |
| Other conifer | Sawara cypress | | Japanese zelkova |
| | Hiba arborvitae | | Cercidiphyllum |
| | Momi fir | | Japanese big-leaf magnolia |
| | Japanese hemlock | | Maple tree |
| | Japanese umbrella pine | | Amur cork |
| | Japanese yew | | Japanese lime |
| | Ginkgo | | Linden |
| | Exotic conifer trees | | Kalopanax |
| | Other needle leaf | | Paulownia |
| | | | Exotic broad leaf trees |
| | | | Other broad leaf |

➢ ***Segregation of “Forest land remaining Forest land” and “Land converted to Forest land”***

The area of “Forest land remaining Forest land” in a certain year is estimated by multiplying ratios of land, where was not converted to other land-use categories in each year (= 1- land conversion ratio of each year) during the past 20 years, to the total forest land area of 20 years ago. For example, the area of “Forest land remaining Forest land” in FY 1990 is estimated by the following equation.

$$A_{FF,1990} = A_{F,1970} \times (1 - R_{conversion,1971}) \times (1 - R_{conversion,1972}) \times \cdots \times (1 - R_{conversion,1990})$$

$A_{FF,\ 1990}$ : Area of “Forest land remaining Forest land” in FY 1990 (ha)
$A_{F,\ 1970}$ : Total forest land area in FY 1970 (ha)
$R_{conversion,\ year}$ : Ratio of conversion from Forest land to other land-use categories in each year

from FY 1971 to FY 1990 (dimensionless)

The area of "Land converted to Forest land" in a certain year is estimated by subtracting the area of "Forest land remaining Forest land" from the total forest land area in the same year.

In addition, all areas of "Land converted to Forest land" are assumed to be intensively managed forests.

Table 7-6 Area of Forest land remaining Forest land

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Forest land remaining Forest land | kha | 23,583.4 | 23,849.8 | 24,140.9 | 24,515.7 | 24,576.8 |
| Intensive managed forest | kha | 8,921.0 | 9,308.5 | 9,595.4 | 9,861.7 | 9,914.4 |
| Seminatural forest | kha | 13,354.5 | 13,220.3 | 13,195.2 | 13,306.2 | 13,321.5 |
| Forests without standing trees | kha | 1,159.0 | 1,171.0 | 1,197.4 | 1,193.1 | 1,184.7 |
| Bamboo | kha | 149.0 | 150.0 | 152.9 | 154.7 | 156.2 |

Source: Forest Status Survey (Forest Agency)

### 2） *Dead Organic Matter, Soils*

● ***Estimation Method***

In accordance with the decision tree provided in the GPG-LULUCF, carbon stock changes in dead wood, litter and soil in Forest land remaining Forest land are estimated by Tier 3 model method.

Carbon emissions/removals in each pool per unit area are estimated by using CENTURY-jfos model and are multiplied by land area of each forest management type. The sum of all forest management types are the annual changes in total carbon stocks in dead wood, litter and soil.

$$\Delta C_{dls} = \sum_{k} (A_k \bullet (d_k + l_k + s_k))$$

$\triangle C_{dls}$ : Annual change in carbon stocks in dead wood, litter and soil [t-C/yr]

$A$ : Area [ha]

$d$ : Average carbon stock change in dead wood per area [t-C/yr]

$l$ : Average carbon stock change in litter per area [t-C/yr]

$s$ : Average carbon stock change in soil per area [t-C/yr]

$k$ : Type of forest management

● ***Parameters***

Average carbon stock changes per unit area for dead wood, litter and soils are calculated by CENTURY-jfos model, which was modified from the CENTURY model (Colorado State University) to be applicable to Japanese climate, soil, and vegetation conditions.

Forestry and Forest Products Research Institute adjusted CENTURY model to Japanese forest environment. That is, the forest was classified by the predominant tree species (Table 7-5, classification before 2004) and the distribution of the tree species and soil types underneath was identified for each prefecture. Climate conditions to run the model were collected from the mesh climate data provided by the Meteorological Agency. Tuning of parameters in CENTURY model was evaluated by the condition that result of tree growth pattern in CENTURY was comparable to the result obtained by the accounting method for carbon stock in living biomass using yield table (5.A.1.-) and also by the condition that soil and litter carbon stocks in the steady state in CENTURY was comparable to the actual carbon stock estimates based on field observation in each prefecture. After these modifications, the CENTURY was renamed to CENTURY-jfos. Then, carbon stocks in dead wood, litter and soil, and their stock changes were calculated by CENTURY-jfos for different forest management types such as management with thinning and without thinning.
In each forest management type total carbon stock changes in deed wood, litter, and soil during 0 – 19 age classes (for 100 years), calculated by CENTURY-jfos, were averaged, which allow us to use the same activity data as those for living biomass accounting.

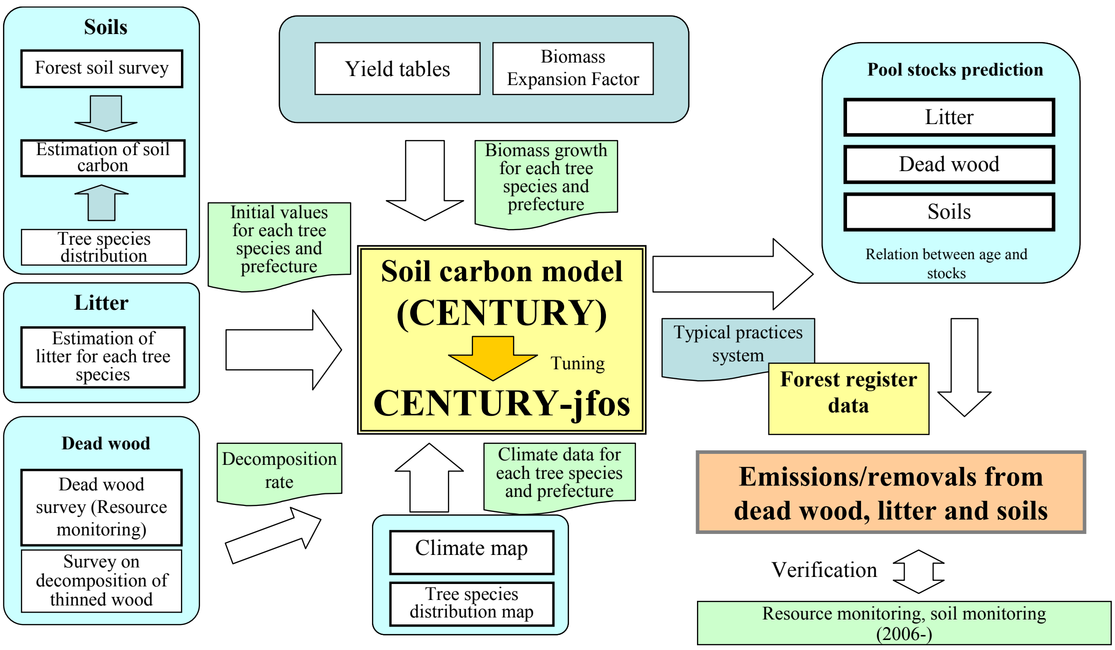


Figure 7-6 Estimation of removals in dead wood, litter and soils

● ***Activity Data***

Forest area data provided in the National Forest Resource Database (NFRDB) were used.

### 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 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 6% for the entire removal by Forest land remaining Forest land. The methodology used in the uncertainty assessment is described in Annex 7. Uncertainty estimates regarding major parameters in this category are as follows:

Table 7-7 Uncertainty estimates regarding major parameters in the Forest land category

| | | | Uncertainty Estimates (%) | Country Specific (CS) or Default(D) | Remarks |
|---|---|---|---|---|---|
| Forest land Area | Intensively Managed Forest | | 5.9 | CS | Estimated based on uncertainty estimates of land areas in the National Forest Resources Database. Used 5.9% without distinguishing tree species. |
| | Semi-natural Forest | | 5.9 | CS | |
| 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 | GPG-LULUCF default value. Used 2.0% without distinguishing tree species. |

- ***Time-series Consistency***

There were no activity data for forest areas for FY 1991 to FY 1994, FY 1996 to FY 2001, and FY 2003 to FY 2004. Therefore, the time-series consistency of the activity data was ensured by estimating the forest areas by means of interpolation.

Carbon stock changes in dead organic matter and soil prior to FY 2004 were not estimated, and their time-series consistency was not ensured. Hence, the estimation method for the carbon stock changes from FY1990 to 2004 need to be considered.

Moreover, some biomass expansion factors, root-to-shoot ratios and wood densities are updated based on newly obtained data and applied to the FY 2007 estimates, but they are not applied to the estimates from FY 1990 to FY 2006. Therefore, it needs to be considered whether the updated values are appropriate to be applied to the estimates from FY 1990 to FY 2006 in order to assure time-series consistency, or the values do not have to be applied to the estimates because the previous values fit actual conditions of the estimates.

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

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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*

No recalculations were implemented because there was no change for this subcategory.

### f) *Source-/Sink-specific Planned Improvements*

● ***Time-series consistency of carbon stock changes in dead organic matter and soil***

The time-series consistency of carbon stock changes in dead organic matter and soil is not ensured. Presently, the estimation method for the carbon stock changes from FY 1990 to FY 2004 is being considered.

## 7.3.2. Land converted to Forest land (5.A.2)

### a) *Source/Sink Category Description*

This subcategory deals with the carbon changes in lands converted to Forest land, which were converted from other land-use categories to Forest land within 20 years by FY 2007. The net removal by this subcategory in FY 2007 was 1,272 Gg-$CO_2$; this represented a decrease of 77.5% over the FY 1990 value and a decrease of 14.2% over the FY 2006 value.

### b) *Methodological Issues*

### 1) *Carbon stock change in Living Biomass*

● ***Estimation Method***

Carbon stock change in living biomass in land converted to Forest land has been calculated, using Tier 2 Stock change method in accordance with page 3.18 of the GPG-LULUCF. In this method, biomass stock change is estimated by the difference between the biomass at time t2 and time t1, additionally subtracted biomass stock change due to land conversion.

$$\Delta C_{LB} = \Delta C_{SC} - \Delta C_{L}$$

$\Delta C_{LB}$ : Carbon stock changes in living biomass (tC/yr)

$\Delta C_{SC}$ : Carbon stock changes due to biomass growth, fellings, fuelwood gathering, disturbance after land conversion (tC/yr)

$\Delta C_{L}$ : Carbon stock changes due to land conversion (tC/yr)

➢ ***Carbon stock change due to biomass growth, fellings, fuelwood gathering and disturbance after land conversion***

Along with carbon stock change in living biomass in Forest land remaining Forest land, Tier 2 method is applied.

$$\Delta C_{SC} = \sum_{k} \left\{ (C_{t2} - C_{t1}) / (t_2 - t_1) \right\}_k$$

$\Delta C_{SC}$ : annual change in carbon stocks in living biomass (tC/yr)

$t_1, t_2$ : time point of carbon stock measurement

$C_{t2}$ : total carbon in biomass calculated at time $t_2$ (tC)

$C_{t1}$ : total carbon in biomass calculated at time $t_1$ (tC)

$k$ : type of forest management

### ➢ *Carbon stock change due to land conversion*

Carbon stock change due to land conversion has been calculated as follows, using method in accordance with the GPG-LULUCF.

$$\Delta C_L = \sum_i \{A_i \times (B_a - B_{b,i}) \times CF\}$$

$\Delta C_L$ : annual biomass carbon stock change in land that has been converted from other land use type to forest (tC/yr)

$A_i$ : land area that has been converted from land use type $i$ to forest (ha/yr)

$Ba$ : dry matter weight immediately after the conversion to forest (t-dm/ha)

$Bb,i$ : dry matter weight before the conversion from land use type $i$ to forest (t-dm/ha)

$CF$ : carbon fraction of dry matter (tC/t-dm)

$i$ : type of land use

### ● *Parameters*

Carbon stock after and before conversion is set as below.

Table 7-8 Biomass stock data for each land use category

| Land use category | | | Biomass stocks [t-dm/ha] | Note |
|---|---|---|---|---|
| Before conversion | Cropland | rice field | 0.00 | Assume as zero |
| | | upland field | 0.00 | Assume as zero |
| | | Orchard | 30.63 | Calculate by multiplying average age and growth rate which are given in Daiyu Ito *et al* "*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*" |
| | Grassland | | 13.50 | *GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet) |
| | Wetlands, Settlements and Other land | | 0.00 | Assume that biomass stocks are "0". |
| Immediately after conversion | Forest | | 0.00 | Assume that biomass stocks immediately after conversion are "0". |

### ● *Activity Data*

The areas of Forest land converted from Cropland and Grassland are determined by applying the data of forested areas that were formerly cultivated land, which are reported in the Statistics of Cultivated and Planted Area. In this reference, the areas are only broken down into rice fields and other fields. Therefore, land areas converted from upland fields, orchards and pasture land to Forest land are estimated by breaking down the area of other fields by means of the existing area ratios of upland fields, orchards and pasture land.

Since the areas of Forest land converted from Wetlands, Settlements, and Other land are not able to be obtained directly from statistics, they are estimated by subtracting areas of Forest land converted from Cropland and Grassland, from the total area of Land converted to Forest land (the estimation method of Land converted to Forest land is described in the "Activity Data" in section 7.3.1 b) 1)). The areas of Forest land converted from Wetlands, Settlements and Other land are reported collectively in "Other land converted to Forest land".

It should be noted that the activity data presented in the CRF "Table 5.A SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Forest land" are not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

Table 7-9 Land converted to Forest land (single year)

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Forest land | kha | 63.9 | 1.5 | 5.9 | 0.6 | 0.6 |
| Cropland converted to Forest land | kha | 2.7 | 1.2 | 1.1 | 0.5 | 0.5 |
| Rice field | kha | 0.9 | 0.5 | 0.4 | 0.2 | 0.2 |
| Upland field | kha | 1.3 | 0.6 | 0.5 | 0.2 | 0.2 |
| Orchard | kha | 0.5 | 0.2 | 0.2 | 0.1 | 0.1 |
| Grassland converted to Forest land | kha | 0.7 | 0.3 | 0.3 | 0.1 | 0.1 |
| Wetlands converted to Forest land | kha | IE | IE | IE | IE | IE |
| Settlements converted to Forest land | kha | IE | IE | IE | IE | IE |
| Other land converted to Forest land | kha | 60.6 | 0.0 | 4.6 | 0.0 | 0.0 |

### 2） *Carbon stock change in Dead Organic Matter and Soils*

● ***Estimation Method***

Carbon stock changes in dead wood, litter and soils were calculated under the assumption that these carbon stocks have changed linearly from those in land-use categories other than Forest land to those in Forest land during the past 20 years.

$$\Delta C_{LF,i} = A_i \times (C_{after,i} - C_{before,i}) / 20$$

$\Delta C_{LF,\ i}$ : Annual change in carbon stocks in dead wood, litter or soils in Land converted to Forest land [t-C/yr]

$A$ : Area being converted to Forest land within the past 20 years [ha]

$C_{after,\ i}$ : Carbon stocks in the land-use category i after conversion (forests) [t-C/ha]

$C_{before,\ i}$ : Carbon stocks in a land-use category before conversion [t-C/ha]

$i$ : Land-use category (Cropland, Grassland, Wetlands, Settlements, or Other land)

● ***Parameters***

Data of dead organic matter and soils for Forest land is the same as those provided in Section 7.3.1 "Forest land remaining Forest land". Soil carbon stocks in all land-use categories including Forest land are shown in Table 7-10 below. In addition, soil carbon stocks in Wetlands, Settlements and Other land are presently under investigation, and will be set again when data become available.

Table 7-10 Soil carbon stocks

| Category | Values used | Note |
|---|---|---|
| Forest land | 84.95 (t-C/ha)<br>(FY 2007) | Value of soil carbon stocks for 0-30 cm depth.<br>National average value calculated by CENTURY-jfos model based on Kazuhito Morisada, Kenji Ono, Hidesato Kanomata "*Organic carbon stock in forest soil in Japan*" Geoderma 119 (2004), p.21-32. This value varies every year.<br>(Reference values)<br>FY 1990: 85.87 tC/ha<br>FY 2000: 85.87 tC/ha<br>FY 2006: 86.06 tC/ha |
| Rice field | 71.38 (t-C/ha) | Value of soil carbon stocks for 0-30 cm depth.<br><br>Data provided from Dr. Makoto Nakai , National Institute for Agro-Environmental Sciences (Undisclosed) |
| 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 | - | Under investigation |
| Other land | - | Under investigation |

➢ ***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 is 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 weighted averaging of soil carbon stock data per unit area at 0-30 cm depth by area for each soil group.

Table 7-11 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 |

*: This mark means the data that are difficult to obtain high-accuracy.

Table 7-12 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 |

*: This mark means the data that are difficult to obtain high-accuracy.

Table 7-13 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 |

*: This mark means the data that are difficult to obtain high-accuracy.

- ***Soil carbon stocks in Grassland***

As is the case with the soil carbon stocks in rice field, upland field and orchard, data from the country-specific soil survey data is applied for the carbon stocks in Grassland soils. Although it is difficult to obtain area data by soil types for Grassland, it could be viewed that the area by soil types and the numbers of samples by soil types have a high correlation; therefore, it is calculated by weighted averaging of soil carbon stock data by the number of samples for each soil group.

Table 7-14 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 |

*: This mark means the data that are difficult to obtain high-accuracy.

➢ ***Transition duration***

Default value (20 years) given in GPG-LULUCF is used. It is assumed that soil organic carbon before 20 years is the same as values for FY 1990.

● ***Activity Data***

The areas of land converted to Forest land within 20 years are calculated by summing land areas during the past 20 years from an estimated year. The area of land converted from Other land to Forest land within 20 years is calculated by subtracting areas of land converted from rice fields, upland fields, orchard and Grassland to Forest land within 20 years from the total areas of land converted to Forest land within 20 years. The areas of land converted from Wetlands and Settlements to Forest Land are included in Other land; therefore, they are reported as "IE" (It is assumed that no land subject to new forest planting during the past 20 years has been converted to another use). For Activity data, refer to Table 7-15.

➢ ***Activity Data of Land converted from Rice Fields, Upland Fields, Orchards and Grassland to Forest Land***

$$A_{LF,i,20years} = \sum_{n=1}^{20} (A_{LF,i,n})$$

$A_{LF,\ i,\ 20\ years}$ : Area of land converted from rice fields, upland fields, orchards or Grassland to Forest land within the past 20 years from an estimated year (kha/20yrs)

$A_{LF,\ i,\ n}$ : Area of land annually converted from rice fields, upland fields, orchards or Grassland to Forest land "n" years before an estimated year (kha/yr)

$i$ : Land-use category before conversion (rice fields, upland fields, orchards or Grassland)

$n$ : 1 – 20 years (n = 1 means the estimated year)

➢ ***Activity Data of Land converted from Other land to Forest land***

$$A_{OF,20years} = A_{LF,total,20years} - \sum(A_{LF,i,20years})$$

$A_{OF,\ 20years}$ : Area of land converted from Other land to Forest land within 20 years (kha/20yrs)

$A_{LF,\ total,\ 20\ years}$ : Total area of land converted to Forest land within 20 years (kha/20yrs)

$A_{LF,\ i,\ 20\ years}$ : Area of land converted from rice fields, upland fields, orchards or Grassland to Forest land within 20 years (kha/20yrs)

$i$ : Land-use category before conversion (rice fields, upland fields, orchards or Grassland)

Table 7-15 Land converted to Forest land within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Forest land | kha | 1,366.8 | 1,047.1 | 735.2 | 470.7 | 405.8 |
| Cropland converted to Forest land | kha | 121.9 | 57.7 | 40.6 | 28.3 | 26.8 |
| Rice field | kha | 53.8 | 23.7 | 15.9 | 10.4 | 9.6 |
| Upland field | kha | 46.8 | 23.7 | 17.7 | 13.3 | 12.8 |
| Orchard | kha | 21.4 | 10.3 | 6.9 | 4.6 | 4.4 |
| Grassland converted to Forest land | kha | 19.3 | 11.6 | 9.0 | 7.0 | 6.7 |
| Wetlands converted to Forest land | kha | IE | IE | IE | IE | IE |
| Settlements converted to Forest land | kha | IE | IE | IE | IE | IE |
| Other land converted to Forest land | kha | 1,225.6 | 977.8 | 685.5 | 435.4 | 372.3 |

### 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 GPG-LULUCF. As a result, the uncertainty estimate was 6% for the entire removal by land converted to Forest land. 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 illustrated in future submissions after investigation is completed.

● ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

### d） Source-/Sink-specific QA/QC and Verification

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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

The soil carbon stock in Other land is determined to be reexamined; therefore, the soil carbon stock change in Other land converted to Forest land comes not to be estimated and is reported as “NE”.

### f） Source-/Sink-specific Planned Improvements

● ***Carbon Stock Changes in the Forest Land converted from Cropland***

It is necessary to obtain data on the areas of rice fields, upland fields, and orchards to estimate the carbon stock changes in Forest land converted from Cropland. Currently, area data cannot be obtained directly from statistics such as the *Statistics of Cultivated and Planted Area*. Hence, areas converted to Forest land from rice fields, upland fields, and orchards are estimated by multiplying the total areas converted from Cropland to Forest land by each area ratio of rice fields, upland fields, and orchards. However, this estimation method may not represent the true status of these areas. Therefore, the validity of the estimation method is presently being reviewed.

- ***Carbon Stock Changes in Soil in Forest Land converted from Other land***

The soil carbon stock in Other land is determined to be reexamined; therefore, the soil carbon stock change in Other land converted to Forest land comes not to be estimated and is reported as "NE". Consideration for the estimation method will be implemented when new data and information are obtained.

## 7.4. 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 FY 2007, Japan's cropland area was about 4.03 million ha, which is equivalent to about 10.7% of the national land. The emissions from this category in FY 2007 were 265 Gg-$CO_2$ (excluding 7.9 Gg-$CO_2$ eq. of $N_2O$ emissions resulting from disturbance associated with land-use conversion to Cropland and 230 Gg-$CO_2$ of $CO_2$ emissions resulting from lime application to Cropland), which was a 87.1% decrease over the FY 1990 value and a 3.4% increase over the FY 2006 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.

### 7.4.1. Cropland remaining Cropland (5.B.1)

#### *a) Source/Sink Category Description*

This subcategory deals with carbon stock changes in the Cropland, which has remained as Cropland during the past 20 years.

With respect to living biomass, the carbon stock change in perennial tree crops (fruit trees) is the subject of estimation according to GPG-LULUCF. However, in Japan, tree growth is limited by trimming in order to have high productivity by keeping the tree height low, and managed and improved the tree shape by pruning lateral branches. Therefore, carbon accumulation because of the tree growth can not expected, and the annual carbon fixing volume of perennial tree crops in all orchards is stated as "NA."

Although the estimation method for dead organic matter is not given in GPG-LULUCF, an estimate input cell is found in CRF. Therefore, carbon stock change in dead organic matter is reported as "NE".

With respect to soil, its carbon stock change is reported as "NA" according to Tier 1 given in GPG-LULUCF, because soil carbon stocks are assumed not to have changed during the past 20 years regardless of any changes in management practices.

### b） *Source-/Sink-specific Planned Improvements*

● ***Carbon Stock Changes in Soils as a result of Changes in Agricultural Management Practices***

It is assumed that carbon stock in soil has not changed as a result of changes in agricultural management practices during the past 20 years. However, this assumption may differ from the actual situations. If the effects of management practice changes are not negligible, the methods used to obtain data on the area of each land use and each agricultural management practice (i.e., type of tillage and quantity of organic matter applied) will need to be examined.

## 7.4.2. 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. The $CO_2$ emissions from this subcategory in FY 2007 were 265 Gg-$CO_2$ (excluding 7.9 Gg-$CO_2$ of $N_2O$ emissions resulting from disturbance associated with land-use conversion to Cropland and 230 Gg-$CO_2$ of $CO_2$ emissions resulting from agricultural lime application); this represents a decrease of 87.1% over the FY 1990 value and an increase of 3.4% over the FY 2006 value.

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 and subsequent gain of living biomass in the land before and after conversion.

With respect to dead organic matter, Japan introduced the Century-jfos model for the FY 2005 estimation, and it became possible to estimate carbon stock changes of dead organic matter in Forest land. Therefore, carbon stock changes in the dead organic matter in Cropland converted from Forest land have been estimated and reported since FY 2005.

With respect to soil, its carbon stock change as a result of land use conversion from other land use to Cropland is estimated. Since it is assumed that there is no organic soil in Japan, all soils are regarded as mineral soils.

### b） *Methodological Issues*

### 1） *Carbon stock change in Living Biomass*

● ***Estimation Method***

The Tier 2 method is applied to the case of Forest land converted to Cropland. The Tier 1 method is used for the case of land uses other than Forest land converted to Cropland. Provisional and default values of the amount of biomass accumulation are used for the Tier 1 method.

$$\Delta C = \Delta C_{Losses} + \Delta C_{Gains}$$

$$\Delta C_{Losses} = \sum_i \left\{ A_i \times (B_{after} - B_{before,i}) \times CF \right\}$$

$$\Delta C_{Gains} = A_{orchard} \times B_{orchard} \times CF$$

$\Delta C$ : carbon stock change in Cropland converted from other land use i within a year (tC/yr)

$\Delta C_{Losses}$ : carbon stock change upon land use conversion from other land use i to Cropland within a year (tC/yr)
$\Delta C_{Gains}$ : carbon stock change associated with biomass growth in converted Cropland within a year (tC/yr)
$A_i$ : area of land converted from other land i to Cropland within a year (ha)
$B_{after}$ : weight of living biomass (dry matter basis) immediately after land use conversion to Cropland (t-dm/ha), default value = 0
$B_{before,i}$ : weight of living biomass (dry matter basis) in land use i before land use conversion (t-dm/ha)
$CF$ : carbon fraction of dry matter (tC/t-dm)
$A_{orchard}$ : area of land converted from other land i to orchard within a year (ha)
$B_{orchard}$ : weight of living biomass (dry matter basis) in converted orchard within a year (t-dm/ha)
$i$ : land use (Forest land, Grassland, Wetlands, Settlements, Other land)
Note: Carbon stock change in living biomass in orchard is assumed to be completed within a year when land conversion is taken place (no further change is expected in following years).

● ***Parameters***

The values shown in Table 7-16 are used for the estimation of biomass stock changes upon land use conversion and subsequent changes in biomass stock because of biomass growth in the converted land.

Table 7-16 Biomass stock data for each land use category

| Land use category | | | Biomass stocks [t-dm/ha] | Note |
|---|---|---|---|---|
| Before conversion | Forest land | | 126.3 (the FY 2007 value) | It is calculated by the Forest Status Survey (Forest Agency) and data provided by the Forest Agency. This value varies every year.<br>(Reference values)<br>FY 1990: 92.9 t-dm/ha<br>FY 2000: 111.1 t-dm/ha<br>FY 2006: 123.7 t-dm/ha |
| | Grassland | | 13.50 | *GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet) |
| | Wetlands, Settlements and Other land | | 0.00 | Assume that biomass stocks are "0". |
| Immediately after conversion | Cropland | | 0.00 | Assume that biomass stocks immediately after conversion are "0". |
| After conversion | Cropland | rice field | 0.00 | Assume that biomass stocks are "0". |
| | | upland field | 0.00 | Assume that biomass stocks are "0". |
| | | orchard | 30.63 | Calculate by multiplying average age and growth rate which are given in Daiyu Ito *et al* "*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*" |

➢ ***Carbon Fraction of Dry Matter***

0.5 (tC/t-dm) (GPG-LULUCF, default value)

● ***Activity Data***

The area of land that has been converted from Forest land to Cropland is determined by referring to the *World Census of Agriculture and Forestry* and to statistics based on the Forestry Agency records.

The area of land that has been converted from the land other than Forest land to Cropland is determined by referring to the expansion area values stated in the *Statistics of Cultivated and Planted Area*. The converted areas found in those information sources are divided proportionately into rice fields, upland fields, orchards, and pasture land based on the current area ratios. The rice fields, upland fields, and orchards are allocated to Cropland, while the pasture land is allocated to grassland.

It should be noted that the activity data presented in the CRF "Table 5.B SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Cropland" is not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

Table 7-17 Area of land converted to Cropland (single year)

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Cropland | kha | 8.8 | 5.6 | 4.5 | 5.0 | 2.4 |
| Forest land converted to Cropland | kha | 5.2 | 1.1 | 0.4 | 0.4 | 0.5 |
| Grassland converted to Cropland | kha | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Wetlands converted to Cropland | kha | 0.3 | 0.0 | 0.1 | 0.0 | 0.0 |
| Settlements converted to Cropland | kha | IE | IE | IE | IE | IE |
| Other land converted to Cropland | kha | 3.3 | 4.5 | 4.0 | 4.6 | 2.0 |

### 2） *Carbon Stock Change in Dead Organic Matter and in Soils*

● ***Estimation Method***

Carbon stock changes in dead wood, litter and soils were calculated under the assumption that these carbon stocks have changed linearly from those in land-use categories other than Forest land to those in Forest land during the past 20 years. Since all soils are regarded as being mineral, organic soil is reported as "IE".

$$\Delta C_i = A_i \times (C_{after,i} - C_{before,i}) / 20$$

- $\Delta C_i$ : Annual change in carbon stocks in dead wood, litter or soils in Land converted to Cropland [t-C/yr]
- $A_i$ : Area being converted to Cropland land within the past 20 years [ha]
- $C_{after,\ i}$ : Carbon stocks in the land-use category i after conversion (Cropland) [t-C/ha]
- $C_{before,\ i}$ : Carbon stocks in a land-use category before conversion [t-C/ha]
- $i$ : Land-use category (Forest land, Grassland, Wetlands, Settlements, or Other land)

● ***Parameters***

➢ ***Carbon Stocks in Dead Organic Matter***

Carbon stocks in dead wood and litter in Forest land before conversion were respectively determined as 15.20 tC/ha and 6.69 tC/ha as the FY 2007 values, based on the Century-jfos model. For non-Forest lands, however, both of them are set to 0 (zero).

➢ ***Carbon Stocks in Soils***

Data listed in Table 7-10 are applied.

● ***Activity Data***

The area of land that was converted to Cropland 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 Cropland in those years. The activity data are shown in Table 7-18.

Table 7-18 Area of land converted to Cropland within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Cropland | kha | 475.9 | 279.5 | 155.9 | 83.0 | 72.1 |
| Forest land converted to Cropland | kha | 174.2 | 118.7 | 72.5 | 28.5 | 24.7 |
| Grassland converted to Cropland | kha | 11.2 | 5.7 | 1.0 | 0.9 | 0.9 |
| Wetlands converted to Cropland | kha | 11.4 | 3.4 | 1.7 | 0.9 | 0.8 |
| Settlements converted to Cropland | kha | IE | IE | IE | IE | IE |
| Other land converted to Cropland | kha | 279.1 | 151.7 | 80.8 | 52.7 | 45.8 |

### 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 GPG-LULUCF. The uncertainty was estimated as 17% for the entire removal 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 7-19 as an example.

Table 7-19 Uncertainty estimates regarding major parameters in the category of Cropland category

| | | Uncertainty (%) | Country Specific (CS) or Default (D) | |
|---|---|---|---|---|
| Cropland Area | Rice Field | 0.15 | CS | Original uncertainty of statistics |
| | Upland Field | 0.27 | CS | |

● ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

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

Quality control (QC) is implemented in accordance with the Tier 1 approach described in GPG (2000) and 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*

● ***Living Biomass Stock Change in the Cropland converted from Other Land Uses Categories***

Since GPG-LULUCF only calls for estimation of the biomass of perennial tree crops (fruit trees) for Cropland, and since yearly biomass increase for annuals is assumed to be the same as loss from harvest or natural death, biomass stock for rice fields and upland fields was re-set to 0 (zero), and living biomass stock changes were re-estimated accordingly.

● ***Soil Carbon Stock Change as a Result of Land Use Conversion from Other Land to Cropland***

Cropland recovery is regarded as the land use conversion from Other land to Cropland and to grassland. Weighted average of soil carbon stock for rice fields, upland fields and orchards was used as the soil carbon stock for the Other land. Therefore, the land use conversion either from rice fields or orchards to Other land showed the decrease of carbon stock; while the conversion from upland fields showed the increase. However, the likelihood with this method is that the resulting change in soil carbon stock as a result of recovery merely reflects the difference between the carbon stock value for the Other land and the individual one for rice fields, upland fields and orchards rather than changes derived from change in land use. Therefore, the use of the weighted average was considered improper for this estimation. Considering that GPG-LULUCF also permits the omission of carbon stock changes caused by natural disturbance if it eventually returns to its former level, soil carbon stock changes upon Cropland recovery were omitted this year and reported as “NE”.

### *f) Source-/Sink-specific Planned Improvements*

- ***Estimation Method of the Area converted from Forest Land to Cropland***

The area converted from Forest land to Cropland was estimated by multiplying the summed area converted to Cropland and grassland by the ratio of Cropland to the summed area. However, this estimation method may not represent the true status of these areas. Therefore, the validity of the estimation method needs to be reviewed, and a new estimation method should be considered if necessary.

- ***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 currently available statistics, so the carbon stock changes in the areas have not been estimated. Therefore, the methods of obtaining the following area data need to be investigated.

- from pasture land to upland field
- from pasture land to orchard
- from grazing meadow to rice field
- from grazing meadow to upland field
- from grazing meadow to orchard

- ***Estimation Method of Soil Carbon Stock Change upon Land Use Conversion from Other Land to Cropland***

Consideration for the estimation method will be implemented when new data and information are obtained.

## 7.5. Grassland (5.C)

Grassland is generally covered with perennial pasture and is used mainly for harvesting fodder or grazing.

In FY 2007, Japan’s grassland area was about 0.91 million ha, which is equivalent to about 2.4% of the national land. The net $CO_2$ removals from this category in FY 2007 were 615 Gg-$CO_2$ (excluding 230 Gg-$CO_2$ of $CO_2$ emissions resulting from agricultural lime application), which was a 19.1% increase over the FY 1990 value and a 1.0% decrease over the FY 2006 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.

### 7.5.1. Grassland remaining Grassland (5.C.1)

***a) Source/Sink Category Description***

This subcategory deals with carbon stock changes in the grassland, which has remained as grassland during the past 20 years.

With respect to living biomass, its carbon stock change is assumed to be constant and reported as "NA" according to Tier 1.

Although the estimation method for dead organic matter is not given in GPG-LULUCF, an estimate, input cell is found in CRF. Therefore, carbon stock change in dead organic matter is reported as "NE".

With respect to soil, its carbon stock change is reported as "NA" according to Tier 1 given in the GPG-LULUCF, because soil carbon stocks are assumed not to have changed during the past 20 years regardless of any changes in management practices.

### 7.5.2. 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 $CO_2$ removal from this subcategory in FY 2007 was 615 Gg-$CO_2$ (excluding 230 Gg-$CO_2$ of $CO_2$ emissions resulting from agricultural lime application); this represents an increase of 19.1% over the FY 1990 value and a decrease of 1.0% over the FY 2006 value.

With respect to living biomass, its carbon stock change as a result of land use conversion from other land use to grassland is estimated. This process includes both temporary loss and subsequent gain of living biomass in the land before and after conversion.

With respect to dead organic matter, Japan introduced the Century-jfos model for the FY 2005 estimation, and it became possible to estimate carbon stock changes of dead organic matter in Forest land. Therefore, carbon stock changes in the dead organic matter in grassland converted from Forest land have been estimated and reported since FY 2005.

With respect to soil, its carbon stock change as a result of land use conversion from other land use to grassland is estimated. Since it is assumed that there is no organic soil in Japan, all soils are regarded as mineral soils.

***b) Methodological Issues***

***1) Carbon stock change in Living biomass***

● ***Estimation Method***

The Tier 2 method is applied to the cases of Forest land and Cropland (rice fields) converted to grassland (pasture lands). The Tier 1 method is used for land uses other than Forest land and Cropland (rice fields) converted to grassland (pasture lands).

The biomass growth is assumed to be complete during the first five years after the land use conversion. Therefore, the annual biomass stock change in the living biomass in the grassland is the sum of biomass stock changes over the last five years.

$$\Delta C = \Delta C_{Losses} + \Delta C_{Gains}$$

$$\Delta C_{Losses} = \sum_i \left\{ A_i \times (B_{after} - B_{before,i}) \times CF \right\}$$

$$\Delta C_{Gains} = A_{grassland} \times B_{grassland} \times CF$$

$\Delta C$ : carbon stock change in Grassland converted from other land use i within a year (tC/yr)

$\Delta C_{Losses}$ : carbon stock change upon land use conversion from other land use i to Grassland within a year (tC/yr)

$\Delta C_{Gains}$ : carbon stock change associated with biomass growth in converted Grassland within a year (tC/yr)

$A_i$ : area of land converted from other land i to Grassland within the past 5 years (ha)

$B_{after}$ : weight of living biomass (dry matter basis) immediately after land use conversion to Grassland (t-dm/ha), default value = 0

$B_{before,i}$ : weight of living biomass (dry matter basis) in land use i before land use conversion (t-dm/ha)

$CF$ : carbon fraction of dry matter (tC/t-dm)

$A_{orchard}$ : area of land converted from other land i to orchard within a year (ha)

$B_{orchard}$ : weight of living biomass (dry matter basis) in converted orchard within a year (t-dm/ha)

$i$ : land use (Forest land, Cropland, Wetlands, Settlements, Other land)

Note: Carbon stock change in living biomass in Grassland is assumed to be completed within first 5 years after land conversion is taken place (no further change is expected in 5 years).

- ***Parameters***

> ***Biomass stock in each Land Use Category***

The values shown in Table 7-20 are used for the estimation of biomass stock changes upon land use conversion and subsequent changes in biomass stock because of biomass growth in converted land.

Table 7-20 Biomass stock data for each land use category

| Land use category | | | Biomass stocks [t-dm/ha] | Note |
|---|---|---|---|---|
| Before conversion | Forest land | | 126.3 (the FY 2007 value) | It is calculated by the Forest Status Survey (Forest Agency) and data provided by the Forest Agency. This value varies every year.<br>(Reference values)<br>FY 1990: 92.9 t-dm/ha<br>FY 2000: 111.1 t-dm/ha<br>FY 2006: 123.7 t-dm/ha |
| | Cropland | rice field | 0.00 | Assume that biomass stocks are "0". |
| | | upland field | 0.00 | Assume that biomass stocks are "0". |
| | | orchard | 30.63 | Calculate by multiplying average age and growth rate which are given in Daiyu Ito *et al* "*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*" |
| | Wetlands, Settlements and Other land | | 0.00 | Assume that biomass stocks are "0". |
| Immediately after conversion | Grassland | | 0.00 | Assume that biomass stocks immediately after conversion are "0". |
| After conversion | Grassland | | 2.70 | One-fifth of the default value given in *GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet) |

➢ ***Carbon Fraction of Dry Matter***

0.5 (tC/t-dm) (GPG-LULUCF, default value)

● ***Activity Data***

In the information sources (statistics) indicated below, Grassland is treated as a part of Cropland. Therefore, the procedure to obtain the activity data for the Grassland converted from other land use categories is as follows:

The area of land that has been converted from Forest land to Grassland is determined by referring to *the World Census of Agriculture and Forestry* and the statistics based on the Forestry Agency records. The area of land that has been converted from the land other than Forest land to Grassland is determined by referring to the expansion area values stated in *the Statistics of Cultivated and Planted Area.* The converted areas found in those information sources are divided proportionately into rice fields, upland fields, orchards, and pasture land based on the current area ratios. Then the pasture land was allocated to grassland.

It should be noted that the activity data presented in the CRF "Table 5.C SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Grassland" is not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

Table 7-21 Area of land converted to Grassland within the past 5 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Grassland | kha | 39.9 | 17.4 | 12.0 | 14.3 | 14.3 |
| Forest land converted to Grassland | kha | 3.4 | 1.4 | 0.5 | 0.2 | 0.3 |
| Cropland converted to Grassland | kha | 6.5 | 3.4 | 4.5 | 6.7 | 6.7 |
| Wetlands converted to Grassland | kha | 0.5 | 0.1 | 0.1 | 0.0 | 0.0 |
| Settlements converted to Grassland | kha | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other land converted to Grassland | kha | 29.5 | 12.4 | 6.9 | 7.4 | 7.4 |

### 2） Carbon Stock Change in Dead organic Matter and Soils

● ***Estimation Method***

Carbon stock changes in dead wood, litter and soils were calculated under the assumption that these carbon stocks have changed linearly from those in land-use categories other than grassland to those in grassland land during the past 20 years. Since all soils are regarded as being mineral, organic soil is reported as "IE".

$$\Delta C_i = A_i \times (C_{after,i} - C_{before,i}) / 20$$

$\Delta C_i$ : Annual change in carbon stocks in dead wood, litter or soils in Land converted to Grassland [t-C/yr]

$A_i$ : Area being converted to Grassland within the past 20 years [ha]

$C_{after,\ i}$ : Carbon stocks in the land-use category i after conversion (Grassland) [t-C/ha]

$C_{before,\ i}$ : Carbon stocks in a land-use category before conversion [t-C/ha]

$i$ : Land-use category (Forest land, Cropland, Wetlands, Settlements, or Other land)

● ***Parameters***

➢ ***Carbon Stocks in Dead Organic Matter***

Carbon stocks in dead wood and litter in Forest land before conversion were respectively determined as 15.20 tC/ha and 6.69 tC/ha as the FY 2007 values, based on the Century-jfos model. For non-Forest lands, however, both of them are set to 0 (zero).

➢ ***Carbon Stocks in Soils***

Data listed in Table 7-10 are applied.

● ***Activity Data***

The area of land that was converted to grassland 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 grassland in those years. The activity data are shown in Table 7-22.

Table 7-22 Area of land converted to Grassland within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Grassland | kha | 283.9 | 183.6 | 166.1 | 159.9 | 150.1 |
| Forest land converted to Grassland | kha | 21.7 | 17.0 | 15.8 | 10.0 | 9.2 |
| Cropland converted to Grassland | kha | 27.7 | 21.5 | 27.6 | 43.1 | 43.3 |
| Wetlands converted to Grassland | kha | 1.6 | 1.4 | 1.6 | 1.3 | 1.2 |
| Settlements converted to Grassland | kha | IE | IE | IE | IE | IE |
| Other land converted to Grassland | kha | 232.8 | 143.6 | 121.1 | 105.4 | 96.4 |

### 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 GPG-LULUCF. The uncertainty was estimated as 19% 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 illustrated in future submissions after investigation is completed.

- ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

### d） Source-/Sink-specific QA/QC and Verification

Quality control (QC) is implemented in accordance with the Tier 1 approach described in GPG (2000) and 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

- ***Redistribution of Grassland which was previously included in Other Land***

Analysis of Other land, the result of which is shown in section 7.8.2., revealed that it included some areas that are supposed to be distributed to grassland. Therefore, these lands were re-distributed as being grassland. Since grassland's activity data was changed, recalculation was carried out accordingly.

- ***Living Biomass Stock Change as a Result of Land Use Conversion from Cropland to Grassland***

Since biomass stock for rice fields and upland fields was re-set to 0 (zero), living biomass stock changes as a result of this land use conversion were re-estimated accordingly.

- ***Living Biomass Stock Change in the Grassland converted from Other Land Use Categories***

All biomass stock changes (growth) in grassland had been previously reported in the year in which the land use was converted to grassland. However, based on expert judgment that grassland biomass takes about five years to grow, biomass stock changes were recalculated using a new method that reflects this reality.

- ***Soil Carbon Stock Change as a Result of Land Use Conversion from Other Land to Grassland***

As in "Soil carbon stock changes caused by conversion of Other land to Cropland" (5.B.2 e) Recalculation), changes were omitted and reported as NE.

### 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 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***

Data on the area of land converted from Cropland to Grassland cannot be obtained from current statistics, so the carbon stock changes in the areas have not been estimated. 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 grazing meadow
・from upland field to grazing meadow
・from orchard to grazing meadow

- ***Estimation Method of Soil Carbon Stock Change upon Land Use Conversion from Other Land to Cropland***

Consideration for the estimation method will be implemented when new data and information are obtained.

- ***Method of Obtaining Data and Revising Estimation Methodologies for Living Biomass Stock in the " Grassland other than Pasture Land and grazed Meadow Land"***

It was pointed out by experts that the living biomass stock of the "grassland other than pasture land and grazed meadow land", which was newly re-distributed to from Other land to Grassland this year, is not necessarily identical to the one of "pasture land and grazed meadow land", which were originally classified in Grassland. Therefore, it is necessary to obtain data, which reflect living biomass stock in the former, and to revise the estimation method for that accordingly.

## 7.6. Wetlands (5.D)

Wetlands are the land 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. GPG-LULUCF divides Wetlands into two large groups: peat land and flooded land.

In FY 2007, Japan's wetland area was about 1.33 million ha, which is equivalent to about 3.5% of the national land. The $CO_2$ emissions from this category in FY 2007 were 167 Gg-$CO_2$, which was a 42.9% decrease over the FY 1990 value and a 10.6% decrease over the FY 2006 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.

### 7.6.1. Wetlands remaining Wetlands (5.D.1)

#### *a) Source/Sink Category Description*

This subcategory deals with carbon stock changes in the 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 the peat extraction is not carried out in Japan. (Default value for Japan is not provided in 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".

### 7.6.2. 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 FY 2007 were 167 Gg-$CO_2$; this represents a decrease of 42.9% over the FY 1990 value and a decrease of 10.6% over the FY 2006 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 and subsequent gain of living biomass in the land before and after conversion.

With respect to dead organic matter, Japan introduced the Century-jfos model for the FY 2005 estimation, and it became possible to estimate carbon stock changes of dead organic matter in Forest land. Therefore, carbon stock changes in the dead organic matter in grassland converted from Forest land have been estimated and reported since FY 2005.

With respect to soil, its carbon stock change as a result of land use conversion from other land use to grassland is estimated. Since it is assumed that there is no organic soil in Japan, all soils are regarded as mineral soils.

#### *b) Methodological Issues*

#### *1) Carbon stock change in Living biomass*

- ***Estimation Method***

The Tier 2 method is applied.

$$\Delta C = \Delta C_{Losses} + \Delta C_{Gains}$$

$$\Delta C_{Losses} = \sum_i \left\{ A_i \times (B_{after} - B_{before,i}) \times CF \right\}$$

$\Delta C$ : carbon stock change in Wetlands converted from other land use i within a year (tC/yr)
$\Delta C_{Losses}$ : carbon stock change upon land use conversion from other land use i to Wetlands within a year (tC/yr)
$\Delta C_{Gains}$ : carbon stock change associated with biomass growth in converted Wetlands within a year (tC/yr)
$A_i$ : area of land converted from other land i to Wetlands within a year (ha)
$B_{after}$ : weight of living biomass (dry matter basis) immediately after land use conversion to Wetlands (t-dm/ha), default value = 0
$B_{before,i}$ : weight of living biomass (dry matter basis) in land use i before land use conversion (t-dm/ha)
$CF$ : carbon fraction of dry matter (tC/t-dm)
$i$ : land use (Forest land, Cropland, Grassland, Settlements, Other land)
Note: Carbon stock change in living biomass associated with biomass growth in Wetlands (dam) is assumed to be zero.

● ***Parameters***

➢ ***Biomass stock in each Land Use Category***

The values shown in Table 7-23 used for the estimation of biomass stock changes upon land use conversion and subsequent changes in biomass stock because of biomass growth in converted land.

Table 7-23 Biomass stock data for each land use category

<table>
<tr><th colspan="3">Land use category</th><th>Biomass stocks [t-dm/ha]</th><th>Note</th></tr>
<tr><td rowspan="6">Before conversion</td><td colspan="2">Forest land</td><td>126.3<br>(the FY 2007 value)</td><td>It is calculated by the Forest Status Survey (Forest Agency) and data provided by the Forest Agency. This value varies every year.<br>(Reference values)<br>FY 1990: 92.9 t-dm/ha<br>FY 2000: 111.1 t-dm/ha<br>FY 2006: 123.7 t-dm/ha</td></tr>
<tr><td rowspan="3">Cropland</td><td>rice field</td><td>0.00</td><td>Assume that biomass stocks are “0”.</td></tr>
<tr><td>upland field</td><td>0.00</td><td>Assume that biomass stocks are “0”.</td></tr>
<tr><td>orchard</td><td>30.63</td><td>Calculate by multiplying average age and growth rate which are given in Daiyu Ito et al “Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan”</td></tr>
<tr><td colspan="2">Grassland</td><td>13.50</td><td>GPG-LULUCF Table 3.4.2 and Table 3.4.3 (warm temperate wet)</td></tr>
<tr><td colspan="2">Settlements and Other land</td><td>0.00</td><td>Assume that biomass stocks are “0”.</td></tr>
<tr><td>Immediately after conversion</td><td colspan="2">Wetlands</td><td>0.00</td><td>Assume that biomass stocks immediately after conversion are “0”.</td></tr>
</table>

➢ ***Carbon Fraction of dry matter***

0.5 (tC/t-dm) (GPG-LULUCF, default value)

● ***Activity Data***

The increases in the area of water bodies in each year were calculated based on the variation of existing submerged area over time. The variation data is indicated in the *Dam Yearbook*, which is compiled and published by the Japan Dam Foundation. Since the data of the area of water bodies indicated in *the Dam Yearbook* also include natural lakes, the change in the area of water body, which is not as a result of land use conversion, was excluded.

Concerning the area for each land use category (Forest land, Cropland, etc.) prior to the land use conversion, the ratios of land that was converted from Cropland (and grassland) or Settlements to dams are estimated based on the numbers of submerged dwellings and the area of submerged Cropland for certain large-scale dams. The area that was converted from Forest land to dams was compared with the estimated values that are from *the World Census of Agriculture and Forestry* and statistics based on the Forestry Agency records. In the case of inconsistencies, for example if the area of Forest land converted in that year is larger than the total area converted to dams, priority is given to the value for the area of converted Forest land, and adjusted within the range of the cumulative total dam conversion area since FY 1990 (because the year of dam completion is not necessarily the same as the actual time of conversion).

As for the other categories, the area of converted Cropland is divided proportionately into Cropland and grassland according to the current area ratios of land use categories. After deducting the areas converted from Forest land, Cropland, grassland, and Settlements from the total dam conversion area, the remainder is considered to be the area converted from other land use categories.

It should be noted that the activity data presented in the CRF "Table 5.D SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Wetlands" is not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

Table 7-24 Area of Land converted to Wetlands (single year)

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Wetlands | kha | 0.5 | 1.3 | 1.6 | 2.5 | 0.7 |
| Forest land converted to Wetlands | kha | 0.3 | 1.0 | 1.1 | 0.2 | 0.4 |
| Cropland converted to Wetlands | kha | 0.1 | 0.3 | 0.4 | 0.6 | 0.2 |
| Grassland converted to Wetlands | kha | 0.0 | 0.1 | 0.1 | 0.1 | 0.0 |
| Settlements converted to Wetlands | kha | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other land converted to Wetlands | kha | 0.1 | 0.0 | 0.0 | 1.6 | 0.1 |

### 2） *Carbon Stock Change in Dead Organic Matter and Soils*

● ***Estimation Method***

Carbon stock changes in dead wood, litter and soils were calculated under the assumption that these carbon stocks have changed linearly from those in land-use categories other than Wetlands to those in Wetlands land during the past 20 years. Since all soils are regarded as being mineral, organic soil is reported as "IE".

$$\Delta C_i = A_i \times (C_{after,i} - C_{before,i}) / 20$$

$\Delta C_i$ : Annual change in carbon stocks in dead wood, litter or soils in Land converted to Wetlands [t-C/yr]

$A_i$ : Area being converted to Wetlands within the past 20 years [ha]

$C_{after,\ i}$ : Carbon stocks in the land-use category i after conversion (Wetlands) [t-C/ha]

$C_{before,\ i}$ : Carbon stocks in a land-use category before conversion [t-C/ha]

$i$ : Land-use category (Forest land, Cropland, Grassland, Settlements, or Other land)

● ***Parameters***

➢ ***Carbon Stocks in Dead Organic Matter***

Carbon stocks in dead wood and litter in Forest land before conversion were respectively determined as 15.20 tC/ha and 6.69 tC/ha as the FY 2007 values, based on the Century-jfos model. For non-Forest lands, however, both of them are set to 0 (zero).

➢ ***Carbon Stocks in Soils***

Data listed in Table 7-10 are applied.

● ***Activity Data***

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 activity data are shown in Table 7-25.

Table 7-25 Area of land converted to Wetlands within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Wetlands | kha | 85.6 | 65.4 | 65.5 | 62.0 | 32.9 |
| Forest land converted to Wetlands | kha | 57.7 | 41.6 | 41.9 | 31.9 | 17.6 |
| Cropland converted to Wetlands | kha | 19.0 | 14.1 | 14.0 | 13.5 | 7.2 |
| Grassland converted to Wetlands | kha | 3.5 | 3.2 | 3.2 | 2.8 | 1.5 |
| Settlements converted to Wetlands | kha | 1.1 | 0.8 | 0.8 | 0.8 | 0.4 |
| Other land converted to Wetlands | kha | 4.3 | 5.7 | 5.4 | 13.0 | 6.2 |

### 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 GPG-LULUCF. The uncertainty was estimated as 21% for the entire removal 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 illustrated in future submissions after investigation is completed.

● ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

### d) Source-/Sink-specific QA/QC and Verification

Quality control (QC) is implemented in accordance with the Tier 1 approach described in GPG (2000) and 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

● ***Living biomass stock change as a result of land use conversion from Cropland to Wetlands***

Since biomass stock for rice fields and upland fields was re-set to 0 (zero), living biomass stock changes as a result of this land use conversion were re-estimated accordingly.

● ***Soil carbon stock change as a result of land use conversion from Other land to Wetlands***

The default value (GPG-LULUCF p 3.76, Table 3.3.3 Warm temperate moist, Wetlands soils) was previously used for Wetlands soil carbon stock, but it is slightly larger than that for forest, Cropland, etc., as a result of which the soil carbon stock rises automatically if conversion to a water surface occurs. Since this default value is based on Wetlands, which includes peatland land, rather than water surfaces, and it is difficult for submerged soil to increase carbon stock, soil carbon stock has been assumed not to change after conversion in land use, and has accordingly been reported as “NE”.

### 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 as “water surfaces”, “rivers” and “canals”, as defined in the national land-use classification, and its whole area is estimated by summing the areas covered by these three features However, this estimation method may fail to cover the whole 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***

Moreover, storage reservoirs (excluding dams) can be considered as artificial flooded land, but the area that 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***

Consideration for the estimation method will be implemented when new data and information are obtained.

## 7.7. 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 FY 2007, Japan’s settlement area was about 3.68 million ha, equivalent to about 9.7% of the national land. The net $CO_2$ emissions by this category in FY 2006 were 849 Gg-$CO_2$, which was 72.4% decrease over the 1990 value, and 8.2% decrease over the previous year.

This section divides Settlements into two subcategories, “Settlements remaining Settlements (5.E.1.)” and “Land converted to Settlements (5.E.2.)”, and describes them separately in the following subsections.

Carbon pools estimated in Settlements are living biomass and dead organic matter. Soil carbon stock changes in Settlements are not estimated because their estimation methods are not described in GPG-LULUCF. Nonetheless, the soil carbon stock changes will be estimated, if necessary, when data are obtained from researches.

With respect to activity data, Tier 1a and Tier 1b of 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 more 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; one is urban green facilities established as urban parks and others, and the other is special greenery conservation zones on which conservation measures are applied and permanent protection is ensured.

<Urban green facilities>

- Urban parks, green areas in road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, 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.

### 7.7.1. Settlements remaining Settlements (5.E.1)

#### *a) Source/Sink Category Description*

This subcategory deals with carbon stock changes in living biomass and dead organic matters in urban green areas (special greenery conservation zones, urban parks, green areas in road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings and green areas around public rental housing) in Settlements remaining Settlements, which has remained Settlements without conversion during the past 20 years. The net removal by this subcategory in FY 2007 was 678 Gg-$CO_2$; this represents an increase of 42.4% over the FY 1990 value and an increase of 0.8 % over the FY 2006 value.

#### *b) Methodological Issues*

#### *1) Carbon Stock Changes in Living Biomass*

● ***Estimation Method***

Due to the differences of characteristics of urban green areas, Tier 1a method is used for special greenery conservation zones that are communal green areas, and Tier 1b is used for urban green facilities that are urban parks, green areas in road, green areas on port, green areas around sewage treatment facility, green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings, green areas around public rental housing.

➢ ***Tier 1a: Special Greenery Conservation Zones***

$$\Delta C_{SSaLB} = \Delta C_{LBaG} - \Delta C_{LBaL}$$

$$\Delta C_{LBaG} = A \times PW \times BI$$

$\Delta C_{SSaLB}$ : changes in carbon stocks in living biomass in special greenery conservation zones (t-C/yr)

$\Delta C_{LBaG}$ : gains in carbon stocks due to growth in living biomass in special greenery conservation zones (t-C/yr)

$\Delta C_{LBaL}$ : 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 GPG-LULUCF

$A$ : area of special greenery conservation zones less than or equal to 20 years since designation (ha)

$PW$ : forested area rate (forested area rate per park area) note: assumed as 100%

$BI$ : growth per crown cover area (t-C/ha crown cover/yr)

➢ ***Tier 1b: Urban green facilities (urban parks, green areas on road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings, green areas around public rental housing)***

$$\Delta C_{SSbLB} = \sum (\Delta C_{LBbGi} - \Delta C_{LBbLi})$$

$$\Delta C_{LBbGi} = \Delta B_{LBbG}$$

$$\Delta B_{LBbGi} = \sum NT_{i,j} * C_{Ratei,j}$$

$\Delta C_{SSbLB}$ : changes in carbon stocks in living biomass in urban green areas other than special greenery conservation zones (t-C/yr)

$\Delta C_{LBbG}$ : gains in carbon stocks due to growth in living biomass in urban green areas other than special greenery conservation zones (t-C/yr)
$\Delta C_{LBbL}$ : losses in carbon stocks due to losses in living biomass in urban green areas other than special greenery conservation zones (t-C/yr) Note: assumed as "0" (zero) in accordance with GPG-LULUCF
$\Delta B_{LBbG}$ : Annual biomass growth in urban green areas other than special greenery conservation zones (t-C/yr)
$C_{Rate}$ : Annual biomass growth per tree (t-C/tree/yr)
$i$ : Land type (urban parks, green areas in road, green areas on port, green areas around sewage treatment facility, green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings, or green areas around public rental housing)
$j$ : Tree species

- ***Parameters***
- ***Tier 1a: Annual biomass growth rate per crown cover area (special greenery conservation areas)***

The annual biomass growth rate of trees per crown cover area in special greenery conservation zones is taken as 2.9 [t-C/ha crown cover/yr], the default value indicated in GPG-LULUCF (p. 3.297).

- ***Tier 1b: Annual biomass growth rate per tree (urban green areas other than special greenery conservation areas)***

The following parameters are taken as the annual biomass growth rates per tree in urban green areas other than special greenery conservation zones.

Table 7-26 Annual biomass growth rate per tree in urban green areas

| Land use category | | Annual biomass growth per tree [t-C/tree/yr] | Remarks |
|---|---|---|---|
| Urban green areas in Settlements remaining Settlements | Hokkaido | 0.0097 | Combined default values shown in table 3A.4.1 in page 3.297 in GPG-LULUCF by the distribution ratio of tree types in sampled urban parks. |
| | Areas other than Hokkaido | 0.0091 | |

- ***Activity Data***

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 (estimated by multiplying areas of special greenery conservation zones less than or equal to 20 years since designation by percentages of planted tree areas) are applied as activity data. Tier 1b applies the number of tall trees planted in each object urban green area as activity data.

➢ ***Tier 1a: Tree crown areas (special greenery conservation zones)***

To determine the amount of activity regarding changes in the amount stored in trees in special greenery conservation zones, the area of special greenery conservation zones determined by the Ministry of Land, Infrastructure, Transport and Tourism is multiplied by the tree crown area rate, which is assumed to be 100%.

Table 7-27 Areas of special greenery conservation zones less than or equal to 20 years since designation

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Green space conservation zones | [ha] | 649 | 904 | 1,389 | 2,034 | 2,106 |
| Suburban green space conservation zones | [ha] | 1,247 | 2,744 | 3,373 | 3,456 | 3,456 |
| Total | [ha] | 1,896 | 3,648 | 4,762 | 5,490 | 5,561 |

- ***Tier 1b: Number of tall trees (urban green areas other than special greenery conservation zones)***

Numbers of tall trees in urban green areas mentioned above are calculated according to the same methods used for revegetation activities under Article 3, paragraph 4, of the Kyoto Protocol. Brief descriptions of the calculation methods for each urban green area are stated below. In addition, detailed description of these calculation methods are stated in the "Activity Data" item in section 3.1.1.4.a) in the "Report on Japan's Supplementary Information on LULUCF activities under Article3, Paragraphs 3 and 4 of the Kyoto Protocol".

- ***Urban parks, green areas on port, green areas around sewage treatment facility, green areas along river and erosion control site, green areas around government buildings, and green areas around public rental housing***

Numbers of tall trees in these subcategory are calculated by (1) calculating the areas falling under this category by multiplying each whole area by the area ratio of land conversion for the whole country, and then (2) calculating the numbers of tall trees in the calculated areas by multiplying each of the areas by the number of tall trees per area. The numbers of tall trees per area for each subcategory are shown in the table below.

Table 7-28 Number of tall trees per area

| Item | Unit | Number of tall trees per area | |
|---|---|---|---|
| | | Hokkaido | Areas other than Hokkaido |
| urban parks | tree/ha | 340.1 | 203.3 |
| green areas on port | tree/ha | 340.1 | 203.3 |
| green areas around sewage treatment facility | tree/ha | 129.8 | 429.2 |
| green areas along river and erosion control site | tree/ha | 1,470.8 | 339.0 |
| green areas around government buildings | tree/ha | 112.1 | 112.1 |
| green areas around public rental housing | tree/ha | 262.4 | 262.4 |

- ***Green areas in road***

Activity data (the number of tall trees) in "Remaining green area on road" is calculated by the following procedures.

1. Calculate the number of tall trees planted during 20 years after establishing green areas in road by using data from the "Road Tree Planting Status Survey" which had been implemented in FY 1987, FY 1992, FY 2007 and FY 2008,
2. Multiply the number of tall trees calculated in Step 1 by the ratio of the number of tall trees

planted on the road which planted area is less than 500 $m^2$,

3. Multiply the number of tall trees calculated in Step 2 by the area ratio of land remaining Settlements.

The values of Step 3 become the number of tall trees that are activity data on green areas in road.

- ***Green areas by greenery promoting system for private green space***

Activity data (the numbers of tall trees) are available for each facility. Therefore, total number of tall trees is used as activity data.

### 2） *Carbon Stock Changes in Dead Organic Matters*

This category estimates carbon stock changes in litter in urban parks and green areas on port. 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 on port are not estimated due to the difficulty of obtaining their activity data.

● ***Estimation Method***

A country-specific method is applied for this estimation because a method for carbon stock changes in litter in Settlements is not provided in GPG-LULUCF. The estimation method is described below.

$$\Delta C_{SSLit} = \sum (A_i \times L_{it,i})$$

$\Delta C_{SSLit}$ : Carbon stock changes in litter in Settlements remaining Settlements (t-C/yr)

$A$ : Area of urban parks and green areas on port in Settlements remaining Settlements (ha)

$L_{it}$ : Carbon stock change per area in urban parks or green areas on port (t-C/ha/yr)

$i$ : Land type (urban parks or green areas on port)

● ***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 a tall tree (Hokkaido: 0.0006 [t-C/tree/yr], other prefectures: 0.0009 [t-C/tree/yr]) based on results of field survey in urban parks, and the number of tall trees per area and ratio of litter moved to off-site due to management including cleaning (54.4%). As a result of calculation, carbon stock changes in litter per urban park area are 0.0984 [t-C/ha/yr] for Hokkaido and 0.0830 [t-C/ha/yr] for other prefectures. In addition, carbon fraction in litter is assumed to be 0.05 [t-C/t-dm] which is a default value provided in the GPG-LULUCF.

● ***Activity Data***

Activity data on this category are the same as those on living biomass in urban parks and green areas on port.

### c） *Uncertainties and Time-series Consistency*

● ***Uncertainty Assessment***

The default values shown in GPG-LULUCF page 3.297 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 GPG-LULUCF page 3.298.

Moreover, the uncertainty estimates for living biomass in special greenery conservation zones applies expert judgment according to the decision tree for activity data in 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 area rate.

Meanwhile, the uncertainty estimates for activity data and parameters on urban parks, green areas in road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings and green areas around public rental housing are 67% and 48%, respectively.

As a result, the uncertainty estimate was 82% 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 illustrated in future submissions after investigation is completed.

● ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

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

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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*

● ***Changes in activity data due to addition of urban green areas***

The following green spaces are newly estimated because they were not included in estimates for Settlements remaining Settlements but were estimated under revegetation activities under Article 3, paragraph 4, of the Kyoto Protocol:

・ Green areas on road
・ Green areas on port
・ Green areas around sewage treatment facility
・ Green areas by greenery promoting system for private green space
・ Green areas along river and erosion control site
・ Green areas around government buildings
・ Green areas around public rental housing

Second, Tier 1b is applied to the estimation of living biomass, except for special greenery conservation zones, because it is possible to apply Tier 1b to green spaces other than the special greenery conservation zones. Recalculation was implemented in accordance with the above changes.

● ***Changes in activity data resulting from reclassification of Other land land areas***

Examination of the land included in the Other land category prior to the drafting of the 2009 inventory revealed certain land areas that would better be placed in the Settlements category. These areas were accordingly reclassified as Settlements, and emissions and removals were recalculated accordingly.

### *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 GPG-LULUCF were applied to the 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 most suits the actual situation.

- ***Carbon Stock Changes in Soil***

The carbon stock changes in soil are currently reported as "NE". Consideration for the estimation method will be implemented when new data and information are obtained.

- ***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.

## 7.7.2. 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, 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 introduced the Century-jfos model from the FY 2005 estimation, and it became possible to estimate carbon stock changes of dead organic matter in Forest land. Therefore, carbon stock changes in dead organic matter in Settlements converted from Forest land have been estimated and reported since FY 2005. The net $CO_2$ emissions by this subcategory in FY 2007 were 1,526 Gg-$CO_2$; this represents a decrease of 57.0% over the FY 1990 value and a decrease of 4.4% over the FY 2006 value.

### *b) Methodological Issues*

### *1) Carbon stock change in Living Biomass*

- ***Estimation Method***

Carbon stock changes in living biomass under the 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 areas. The Carbon stock changes in living biomass before and after conversion are estimated by applying the equation of section 3.6.2 in GPG-LULUCF (multiplying the land area converted from each land use to Settlements by the difference between the values of biomass stock before and after conversion, and by the carbon fraction). Biomass stocks in land converted to urban green areas are increased because due to growth of trees planted after conversion. Hence, carbon stock changes in living biomass in land converted to urban green areas are estimated by making carbon stock changes before and after conversion plus annual carbon stock changes after conversion that are estimated by applying Tier 1b method in section 3A.4.1.1.1 in GPG-LULUCF.

$$\Delta C_{LSLB} = \sum (A_I \times (CR_a - CR_{b,I}) \times CF) + \sum (\Delta C_{LS(UG)Gi} - \Delta C_{LS(UG)Li})$$
$$\Delta C_{LS(UG)G} = \Delta B_{LS(UG)G}$$
$$\Delta B_{LS(UG)G} = \sum NT_j \times C_{Ratej}$$

| | |
|---|---|
| $\Delta C_{LSLB}$ | : 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-dm/ha), default＝0 |
| $CR_{b,I}$ | : carbon reserves in land use type *i* immediately before conversion to Settlements (t-dm/ha) |
| $CF$ | : carbon fraction of dry matter (t-C/t-dm) |
| $I$ | : 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 are assumed as “0” (zero) in accordance with GPG-LULUCF |
| $\Delta B_{LS(UG)G}$ | : annual biomass growth in land converted to urban green areas (t-C/yr) |
| $C_{Rate}$ | : annual biomass growth per tree (t-C/tree/yr) |
| $NT$ | : number of trees |
| $i$ | : type of urban green areas after conversion (urban parks, green areas on road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings, or green areas around public rental housing) |
| $j$ | : tree species |

- ***Parameters***

➢ ***Biomass stocks for each land use category***

Table 7-29 shows the biomass stocks before and after conversion. Carbon stock losses due to loss of living biomass are assumed as “0” (zero) in accordance with GPG-LULUCF, because trees subject to estimation are all less than or equal to 20 years old. Table 7-30 shows the annual biomass growth of trees in land converted to urban green areas.

➢ ***Carbon fraction of dry matter***

0.5 (tC/t-dm) (default value, GPG-LULUCF)

➢ ***Biomass stock immediately after conversion***

Carbon stock after and before conversion is set as follows.

Table 7-29 Biomass stock data for each land use category

| Land use category | | | Biomass stocks [t-dm/ha] | Note |
|---|---|---|---|---|
| Before conversion | Forest land | | 126.3 (the FY 2007 value) | It is calculated by the Forest Status Survey (Forest Agency) and data provided by the Forest Agency. This value varies every year.<br>(Reference values)<br>FY 1990: 92.9 t-dm/ha<br>FY 2000: 111.1 t-dm/ha<br>FY 2006: 123.7 t-dm/ha |
| | Cropland | rice field | 0.00 | assumed as "0" (zero) |
| | | upland field | 0.00 | assumed as "0" (zero) |
| | | orchard | 30.63 | Calculate by multiplying average age and growth rate which are given in Daiyu Ito *et al* "*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*" |
| | Grassland | | 13.50 | *GPG-LULUCF* Table 3.4.2 and Table 3.4.3 (warm temperate wet) |
| | Wetlands and Other land | | 0.00 | Assume that biomass stocks are "0". |
| Immediately after conversion | Settlements | | 0.00 | Assume that biomass stocks immediately after conversion are "0". |

Table 7-30 Annual biomass growth of trees in land converted to urban green areas

| Land use category | | Annual biomass growth per tree [t-C/tree/yr] | Remarks |
|---|---|---|---|
| Land converted to urban green areas | Hokkaido | 0.0097 | Combined default values shown in table 3A.4.1 in page 3.297 in GPG-LULUCF by the distribution ratio of tree types in sampled urban parks. |
| | Areas other than Hokkaido | 0.0091 | |

● ***Activity Data***

With respect to area of land converted to Settlements, only the areas converted to Settlements from Forest land, Cropland and Grassland are determined. Since no data is available on the area converted to Settlements from Wetlands or other land use categories, no figures are reported in those land use categories. Instead, they are reported as "IE" and recorded under "Other land remaining Other land." It should be noted that the activity data presented in the CRF "Table 5.E SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Settlements" are not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

➢ ***Conversion from Forest land***

That portion of the area of converted Forest land (estimated according to "World Census of Agriculture and Forestry" and statistics based on Forestry Agency records) which has been converted to Settlements is considered to include land for construction or business sites, land for housing and vacation homes, land for golf courses and other leisure purposes, and land for public uses (excluding land converted to dams).

➢ ***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 7-31 Area of Land converted to Settlements (single year)

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Settlements | kha | 37.5 | 31.7 | 21.2 | 13.6 | 14.0 |
| Forest land converted to Settlements | kha | 13.0 | 9.1 | 4.6 | 2.2 | 2.2 |
| Cropland converted to Settlements | kha | 21.4 | 19.5 | 14.5 | 9.8 | 10.2 |
| Grassland converted to Settlements | kha | 3.2 | 3.1 | 2.2 | 1.5 | 1.6 |
| Wetlands converted to Settlements | kha | IE | IE | IE | IE | IE |
| Other land converted to settlements | kha | IE | IE | IE | IE | IE |

➢ ***Area and number of trees in land converted to urban green areas***

Areas of land converted to urban green areas are calculated by multiplying the whole areas of each urban green area (urban parks, green areas on road, green areas on port, green areas around sewage treatment facility green areas by greenery promoting system for private green space, green areas along river and erosion control site, green areas around government buildings, or green areas around public rental housing) by area ratio of land conversion for the whole country. Numbers of trees are calculated by multiplying each urban green area converted from other land-use categories by number of trees per area. Detailed information regarding these activity data are provided in the "activity data" item in section 3.1.1.4 e) in the "Report on Japan's Supplementary Information on LULUCF activities under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol".

***2） Carbon stock change in Dead organic Matter***

This category estimates 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 on port.

With respect to dead wood, only the carbon stock changes in Settlements converted from Forest land are estimated. Tier 2 method is applied to the estimation in accordance with the method for "conversion from other land use to Cropland" in GPG-LULUCF. Carbon stock changes in dead wood in urban parks and green areas on port are reported as "IE" because they are included in those in their living biomass.

In regard to litter, the carbon stock changes in Settlements converted from Forest land and land converted to urban parks and green areas on port are estimated. Tier 2 method is applied to 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 GPG-LULUCF. Carbon stock changes in litter in land converted to urban parks and green areas on port are estimated by applying Japan's country-specific estimation method due to lack of an estimation method in GPG-LULUCF. Carbon stock changes in litter in land converted to urban green areas other than urban parks and green areas on port are not estimated due to the difficulty of obtaining their activity data.

- ***Estimation Method***

$$\Delta C_{LS} = \Delta C_{FS} + \Delta C_{LSLit}$$

$\Delta C_{FS}$ : Carbon stock changes in dead organic matter in Settlements converted from Forest land (t-C/yr)

$\Delta C_{LSLit}$ : Carbon stock changes in litter in urban parks and green areas on port 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***

$$\Delta C_{FS} = \sum((C_{after,i} - C_{before,i}) \times A / 20)$$

$\Delta C_{FS}$ : Carbon stock changes in dead organic matter in Settlements converted from Forest land (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 land converted from Forest land to Settlements over 20 years (ha)

$i$ : type of dead organic matter (dead wood or litter)

➢ ***Carbon stock changes in litter in Land converted to urban parks and green areas on port***

$$\Delta C_{LSLit} = \sum(A_i \times (C_{AfterLit,i} - C_{BeforeLit,I}) + A_i \times Lit_i)$$

$\Delta C_{LSLit}$ :Carbon stock changes in litter in urban parks and green areas on port converted from land use categories other than Forest land (t-C/yr)

$A$ : Area of urban parks or green areas on port converted from land use categories other than Forest land for one 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 on port converted from land use categories other than Forest land (t-C/ha/yr)

$I$ : Land-use type before conversion

$i$ : Land-use type after conversion (urban parks or green areas on port)

- ***Parameters***

➢ ***Carbon stocks in dead organic matter in Settlements converted from Forest land***

Carbon stocks in dead wood and litter in Forest land before conversion were respectively determined as 15.20 tC/ha and 6.69 tC/ha as the FY 2007 values, based on the Century-jfos model. In addition, the stocks of dead organic matter are estimated under the assumption that they come to be zero immediately after conversion, and are not accumulated after conversion.

➢ ***Carbon stocks in litter in urban parks and green areas on port converted from land use categories other than Forest land***

When urban parks and green areas on port are converted from land use categories other than Forest land, litter stocked before conversion is not moved to off-site because ground before conversion, including litter, are 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 increased 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 used for urban parks and green areas on port in Settlements remaining Settlements due to the research result that the litter stocks are accumulated as same as those in Settlements remaining Settlements by natural drop of fallen leaves and branches from trees in land converted to the urban parks and green areas.

● ***Activity Data***

➢ ***Carbon stocks in dead organic matter in Settlements converted from Forest land***

The area of land that was converted from Forest land to Settlements during the past 20 years is determined by accumulating areas converted from Forest land to Settlements during the past 20 years. For activity data, refer to Table 7-32.

Table 7-32 Area of Land converted to Settlements within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Settlements | kha | 1,493.0 | 1,277.5 | 1,175.7 | 1,014.9 | 1,002.4 |
| Forest land converted to Settlements | kha | 372.2 | 389.7 | 369.5 | 304.7 | 291.2 |
| Cropland converted to Settlements | kha | 1,006.1 | 778.9 | 702.9 | 618.1 | 618.7 |
| Grassland converted to Settlements | kha | 114.7 | 108.9 | 103.3 | 92.1 | 92.5 |
| Wetlands converted to Settlements | kha | IE | IE | IE | IE | IE |
| Other land converted to settlements | kha | IE | IE | IE | IE | IE |

➢ ***Carbon stock changes in litter in Land converted to urban parks and green areas on port***

Areas of land converted to urban green areas are calculated as same as the carbon stock changes in living biomass in land converted to urban green areas. The calculation is to multiply the whole areas of urban parks and green areas on port by area ratio of land conversion for the whole country, respectively. Detailed information regarding these activity data are provided in the "activity data" item in section 3.1.1.4 e) in the "Report on Japan's Supplementary Information on LULUCF activities under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol".

### *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 GPG-LULUCF. The uncertainty estimate was 15% 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 illustrated in future submissions after investigation is completed.

● ***Time-series consistency***

Time-series consistency for this subcategory is ensured.

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

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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*

● ***Changes in activity data resulting from reclassification of Other land areas***

The land included in the Other land category was reclassified prior to the drafting of the 2009 inventory. As a result, it was revealed that certain land areas that would better be placed in the Settlements category. These areas were reallocated to Settlements, and emissions and removals were recalculated, accordingly. For further information regarding this issue, see Section 7.8.2.e).

● ***Changes in Settlementsoil carbon stocks***

The use of the set value for grassland soil carbon stock of 134.91 t-C/ha as a value also for soil carbon stock of land converted to Settlements is being reconsidered since it is thought not to reflect the reality and to be causing discrepancies in carbon stock change estimates. Soil carbon stock changes for the relevant land use categories will accordingly be omitted and reported as “NE” until further knowledge becomes available.

● ***Changes in activity data due to addition of urban green areas***

The following green spaces, which were not included in estimates for land converted to Settlements, were added because they are estimated under revegetation activities under Article 3, paragraph 4, of the Kyoto Protocol:

- Urban parks
- Green areas on road
- Green areas on port
- Green areas around sewage treatment facility
- Green areas by greenery promoting system for private green space
- Green areas along river and erosion control site
- Green areas around government buildings
- Green areas around public rental housing

Moreover, Tier 1b was applied to the estimation of living biomass in the above urban green areas because it is possible to apply Tier 1b. Moreover, carbon stock changes in litter in urban parks and green areas on port converted from land use categories other than Forest land became able to be estimated; hence, Japan estimates these carbon stock changes by applying its country-specific estimation method. Recalculation was implemented in accordance with the above changes.

***f) Source-/Sink-specific Planned Improvements***

● ***Carbon Stock Changes in Soil***

The carbon stock changes in soil are currently reported as “NE”. Consideration for the estimation method will be implemented when new data and information are obtained.

● ***Validity of the Assumption used in the Method of Estimating the Area of Settlements***

Furthermore, the areas of Forest land converted to Settlements are presently assumed as “roads”, “human habitats”, “school reservations”, “park and green areas”, “road sites”, “environmental facility sites”, “defense 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.

## 7.8. Other land (5.F)

Other land consists of land areas that are not included in the other five land-use categories. It includes bare land, rock, ice, and unmanaged land areas. The Other land in Japan includes areas abandoned after cultivation, areas used for national defense, and the northern territories of Japan. In FY 2007, Japan’s Other land area was about 2.86 million ha, which is equivalent to about 7.6% of the national land. The areas are determined by subtracting the summed areas of the other five land-use categories from the national land area shown in *the Land Use Status Survey* compiled by the Ministry of Land, Infrastructure, Transport, and Tourism. The $CO_2$ emissions from this category in FY 2007 were 608 Gg-$CO_2$, which was a 36.5% decrease over the FY 1990 value and a 10.6% decrease/increase over the

FY 2006 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.

### 7.8.1. Other land remaining Other land (5.F.1)

#### *a) Source/Sink Category Description*

This subcategory deals with carbon stock changes in the Other land, which has remained as Other land during the past 20 years. However, changes in carbon stocks and non-$CO_2$ emissions and removals in this subcategory are not considered in accordance with GPG-LULUCF.

#### *b) Source-/Sink-specific Planned Improvements*

- ***Method of Defining Land Areas***

7.6% of the nation's land is categorized as "Other land remaining Other land", and this classification may not fit the actual land status. Therefore, the method of defining land areas, including the other five land-use categories, is now under revision.

- ***Carbon Stock Changes in Living Biomass of Other land remaining Other land***

The carbon stock changes in the living biomass of "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, methods of estimating their carbon stock changes will be examined.

### 7.8.2. Land converted to Other land (5.F.2)

#### *a) Source/Sink Category Description*

This subcategory deals with carbon stock changes, which occurred in the lands that were converted from other land use categories to Other land within the past 20 years. The $CO_2$ emissions from this subcategory in FY 2007 were 608 Gg-$CO_2$; this represents a decrease of 36.5% over the FY 1990 value and a decrease of 10.6% over the FY 2006 value.

With respect to living biomass, its carbon stock change as a result of land use conversion from other land use to Other land is estimated. This process includes both temporary loss and subsequent gain of living biomass in the land before and after conversion.

With respect to dead organic matter, Japan introduced the Century-jfos model for the FY 2005 estimation, and it became possible to estimate carbon stock changes of dead organic matter in Forest land. Therefore, carbon stock changes in the dead organic matter in Other land converted from Forest land have been estimated and reported since FY 2005.

### *b） Methodological Issues*

#### *1） Carbon stock change in Living Biomass*

- ***Estimation Method***

The Tier 2 method is applied.

$$\Delta C = \Delta C_{Losses} + \Delta C_{Gains}$$

$$\Delta C_{Losses} = \sum_i \left\{ A_i \times (B_{after} - B_{before,i}) \times CF \right\}$$

$\Delta C$ : carbon stock change in Other land converted from other land use i within a year (tC/yr)

$\Delta C_{Losses}$ : carbon stock change upon land use conversion from other land use i to Other land within a year (tC/yr)

$\Delta C_{Gains}$ : carbon stock change associated with biomass growth in converted Other land within a year (tC/yr)

$A_i$ : area of land converted from other land i to Other land within a year (ha)

$B_{after}$ : weight of living biomass (dry matter basis) immediately after land use conversion to Other land (t-dm/ha), default value = 0

$B_{before,i}$ : weight of living biomass (dry matter basis) in land use i before land use conversion (t-dm/ha)

$CF$ : carbon fraction of dry matter (tC/t-dm)

$i$ : land use (Forest land, Cropland, Grassland, Wetlands, Settlements)

Note: Carbon stock change in living biomass associated with biomass growth in Other land is assumed to be zero.

- ***Parameters***

➢ ***Biomass stock in each Land Use Category***

The values shown in Table 7-33 are used for the estimation of biomass stock changes upon land use conversion and subsequent changes in biomass stock because of biomass growth in converted land.

Table 7-33 Biomass stock data for each land use category

| Land use category | | | Biomass stocks [t-dm/ha] | Note |
|---|---|---|---|---|
| Before conversion | Forest land | | 126.3 (the FY 2007 value) | It is calculated by the Forest Status Survey (Forest Agency) and data provided by the Forest Agency. This value varies every year. (Reference values) FY 1990: 92.9 t-dm/ha FY 2000: 111.1 t-dm/ha FY 2006: 123.7 t-dm/ha |
| | Cropland | rice field | 0.00 | Assume that biomass stocks are “0”. |
| | | upland field | 0.00 | Assume that biomass stocks are “0”. |
| | | orchard | 30.63 | Calculate by multiplying average age and growth rate which are given in Daiyu Ito *et al* “*Estimating the Annual Carbon Balance in Warm-Temperature Deciduous Orchards in Japan*” |
| | Grassland | | 13.50 | *GPG-LULUCF* Table 3.4.2 and Table 3.4.3（warm temperate wet） |
| | Wetlands and Settlements | | 0.00 | Assume that biomass stocks are “0”. |
| Immediately after conversion | Other land | | 0.00 | Assume that biomass stocks immediately after conversion are “0”. |

➢ ***Carbon Fraction of dry matter***

0.5 (tC/t-dm) (GPG-LULUCF, default value)

● ***Activity Data***

Only the area converted from Forest land and Cropland to Other land is determined. Since no data was available on the area converted from Wetlands and Settlements to Other land, estimations for those land use categories were not possible. Therefore, they were reported as “IE” and reported under “Other land remaining Other land.” It should be noted that the activity data presented in the CRF “Table 5.F SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY－Other land” are not the converted area in FY 2007 but the sum of annually converted areas during the past 20 years.

➢ ***Conversion from Forest Land***

The portion of the area of converted Forest land (estimated according to *the World Census of Agriculture and Forestry* and statistics based on the Forestry Agency records) which has been used as a source of soil and stone or for other purposes is considered to be the area converted to Other land.

➢ ***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 7-34  Area of land converted to Other land (single year)

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Other land | kha | 21.5 | 28.0 | 27.4 | 15.6 | 14.5 |
| Forest land converted to Other land | kha | 2.4 | 2.1 | 1.6 | 1.3 | 1.1 |
| Cropland converted to Other land | kha | 15.3 | 20.0 | 16.8 | 9.2 | 8.9 |
| Grassland converted to Other land | kha | 3.8 | 5.8 | 9.0 | 5.0 | 4.5 |
| Wetlands converted to Other land | kha | IE | IE | IE | IE | IE |
| Settlements converted to Other land | kha | IE | IE | IE | IE | IE |

### 2） *Carbon Stock Change in Dead Organic Matter*

● ***Estimation Method***

Carbon stock changes in dead wood and litter were calculated under the assumption that these carbon stocks have changed linearly from those in land-use categories other than Other land to those in Other land during the past 20 years.

$$\Delta C_i = A_i \times (C_{after,i} - C_{before,i}) / 20$$

$\Delta C_i$ : Annual change in carbon stocks in dead wood or litter in Land converted to Other land [t-C/yr]

$A_i$ : Area being converted to Other land within the past 20 years [ha]

$C_{after,\ i}$ : Carbon stocks in the land-use category i after conversion (Other land) [t-C/ha]

$C_{before,\ i}$ : Carbon stocks in a land-use category before conversion [t-C/ha]

$i$ : Land-use category (Forest land, Cropland, Grassland, Wetlands, or Settlements)

● ***Parameters***

➢ ***Carbon stocks in dead organic matter in Other land converted from Forest land***

Carbon stocks in dead wood and litter in Forest land before conversion were respectively determined as 15.20 tC/ha and 6.69 tC/ha as the FY 2007 values, based on the Century-jfos model. For non-Forest lands, however, both of them are set to 0 (zero).

● ***Activity Data***

The values of annually converted area from each land use category to Other land during the past 20 years are summed up to obtained the total area that is converted to Other land during the same time period.

Table 7-35 Area of Land converted to Other land within the past 20 years

| Category | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Land converted to Other land | kha | 557.0 | 475.0 | 467.9 | 481.7 | 477.3 |
| Forest land converted to Other land | kha | 70.2 | 64.4 | 56.2 | 43.0 | 41.1 |
| Cropland converted to Other land | kha | 419.4 | 336.9 | 313.5 | 316.6 | 312.6 |
| Grassland converted to Other land | kha | 67.3 | 73.7 | 98.1 | 122.1 | 123.6 |
| Wetlands converted to Other land | kha | IE | IE | IE | IE | IE |
| Settlements converted to Other land | kha | IE | IE | IE | IE | IE |

### c） Uncertainties and Time-series Consistency

● ***Uncertainty Assessment***

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 GPG-LULUCF. The uncertainty was estimated as 30% 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 illustrated in future submissions after investigation is completed.

● ***Time-series Consistency***

Time-series consistency for this subcategory is ensured.

### d） Source-/Sink-specific QA/QC and Verification

Quality control (QC) is implemented in accordance with the Tier 1 approach described in GPG (2000) and 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

● ***Breakdown Analysis of Other land and Reclassification into Other Land-Use Categories***

Analysis of the breakdown of Other land revealed land that should be placed in other land-use categories, and the identified land was reallocated accordingly (see Table 7-36). Since this resulted in changes in activity data (see Table 7-37), the latter was recalculated.

Table 7-36 Land included in the Other Land Category before Reallocation (the 1992 values)

(unit: kha)

| Item | | Land Area | Land Category after Reallocation |
|---|---|---|---|
| Other land (Total Area before Reallocation) | | 3,534 | |
| | Wild land | 260 | Grassland |
| | School Reservation | 70 | Settlements |
| | Park and Green Area | 113 | Settlements |
| | Road Site | 80 | Settlements |
| | Environmental Facility Site | 33 | Settlements |
| | Defense Facility Site | 137 | Other land |
| | Golf Course | 99 | Settlements |
| | Ski Course | 18 | Settlements |
| | Other Recreation Site | 54 | Settlements |
| | Cultivation Abandonment Area | 217 | Other land |
| | Coast | 46 | Other land |
| | Northern Territories | 504 | Other land |
| | Other | 1,903 | Other land |

Table 7-37 Land included in the Other Land Category after Reallocation (the 1992 values)

(Unit: kha)

| Item | | Land Area |
|---|---|---|
| Other land (Total Area after Reallocation) | | 2,807 |
| | Defence Facility Site | 137 |
| | Cultivation Abandonment Area | 217 |
| | Coast | 46 |
| | Northern Territories | 504 |
| | Other | 1,903 |

- ***Living Biomass Stock Change as a Result of Land Use Conversion from Cropland to Wetlands***

Since biomass stock for rice fields and upland fields was re-set to 0 (zero), living biomass stock changes as a result of this land use conversion were re-estimated accordingly.

- ***Soil Carbon Stock Change as a Result of Land Use Conversion from Forest to Other Land***

Grassland's soil carbon stock value had been substituted as the soil carbon stock of Other land, which is converted from forest. However, since it is though not to reflect reality, the estimation of soil carbon stock change was omitted and reported as NE.

- ***Soil Carbon Stock Change as a Result of Land Use Conversion from Cropland or Grassland to Other Land***

As in "Soil carbon stock changes as a result of land use conversion from Other land to Cropland"

(5.B.2 e) Recalculations), soil carbon stock change upon the land use conversion from Cropland or grassland to Other land was reported as NE owing to the use of weighted averages for rice fields, upland fields and orchards as the soil carbon stock for Other land (abandoned arable land), and lack of sufficient information regarding soil carbon stocks of abandoned arable land.

- ***Soil Carbon Stock Change as a Result of land Use Conversion from Other Land to Grassland***

As in "Soil carbon stock changes caused by conversion of Other land to Cropland" (5.B.2 e) Recalculation), changes were omitted and reported as NE.

#### *f） Source-/Sink-specific Planned Improvements*

- ***Carbon Stock Changes in Living Biomass of Land converted to Other Land***

The carbon stock changes in living biomass of 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, methods used to quantifying the carbon stock are being examined.

- ***Breakdown Analysis of Other Land and Reclassification into Other Land Use Categories***

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.

- ***Estimation Method of Soil Carbon Stock Change upon Land Use Conversion from Forest, Cropland and Grassland to Other Land***

Consideration for the estimation method will be implemented when new data and information are obtained.

## 7.9. Direct $N_2O$ emissions from N fertilization (5. (I))

#### *a） Source/Sink Category Description*

It is assumed that volume of nitrogen-based fertilizer applied to forest soils is included in demand for nitrogen-based fertilizers in Agriculture sector, although fertilization application in Forest land may not conducted in Japan. Therefore, these sources have been reported as "IE".

## 7.10. $N_2O$ 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 advised that the $N_2O$ emissions are extremely low, because the soil drainage activities are very rarely carried out in Japan. Based on this advice, this category is reported as "NO".

## 7.11. $N_2O$ 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 emission by this subcategory in FY 2006 was 7.9 Gg-$CO_2$; this represents a decrease of 88.5% over the FY 1990 value and a decrease of 11.4% over the FY 2006 value.

### b） *Methodological Issues*

● ***Estimation Method***

According to GPG-LULUCF, Tier 1 method is used.

$$N_2O - N_{conv} = N_2O_{net-\min} - N$$
$$N_2O_{net-\min} - N = EF \times N_{net-\min}$$
$$N_{net-\min} = C_{released} \times 1/C:N_{ratio}$$

| | |
|---|---|
| $N_2O$ - $N_{conv}$ | : $N_2O$ emission due to land-use conversion to Cropland (kg$N_2O$-N) |
| $N_2O_{net\text{-}min}$ - $N$ | : $N_2O$ emission due to land-use conversion to Cropland (kg$N_2O$-N/ha/yr) |
| $N_{net\text{-}min}$ | : annual N emission from soil disturbance associated with mineralization of soil organic matter (kgN/ha/yr) |
| $EF$ | : emission factor |
| $C:N_{ratio}$ | : CN ratio |
| $C_{released}$ | : soil carbon stock that has been mineralized within the past 20 years |

● ***Parameters***

➢ ***C:N ratio for soils***

11.3 (Country specific data (Undisclosed))

➢ ***N-$N_2O$ emission factor for soils***

0.0125 [kg-$N_2O$-N/kg-N] (default value stated in 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 used for soil carbon stock changes in Land converted to Cropland, mentioned in section 7.4.2.2).

### 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 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 76%. 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*

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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*

The activity data on Other land converted to Cropland in this category came to be “NE” because the soil carbon stock changes in Other land converted to Cropland came to be reported as “NE”.

Therefore, the $N_2O$ emissions derived from conversion from Other land to Cropland are also reported as “NE”.

### *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 converted from Forest land to Cropland and from grassland to Cropland need to be improved. Areas converted from Forest land to Cropland and from grassland to Cropland were estimated by multiplying the summed areas converted to Cropland and grassland by the ratio of Cropland to the summed areas. However, this estimation method may not represent the actual status of these areas. The validity of the estimation method therefore 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 Grassland to Cropland***

Moreover, 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 the following area data need to be investigated.

- from pasture land to upland field
- from pasture land to orchard
- from grazing meadow to rice field
- from grazing meadow to upland field
- from grazing meadow to orchard

● ***Estimation Method of Soil Carbon Stock Change in Other land converted to Cropland***

Consideration for the estimation method will be implemented when new data and information are obtained.

## 7.12. $CO_2$ emissions from agricultural lime application (5.(IV))

### *a) Source/Sink Category Description*

This category deals with $CO_2$ emissions from agricultural lime application. The $CO_2$ emissions from this category in FY 2007 were 230 Gg-$CO_2$, which represents a decrease of 58.1% over the FY 1990 value.

### *b) Methodological Issues*

● ***Estimation Method***

Tier 1 method is used in accordance with GPG-LULUCF (page 3.80).

$$\Delta C_{CCLime} = \left(M_{Limestone} \times EF_{Limestone} + M_{Dolomite} \times EF_{Dolomite}\right) \times 44/12$$

| | |
|---|---|
| $\Delta C_{CCLime}$ | : annual $CO_2$ emissions from agricultural lime application ($tCO_2$/yr) |
| $M_{Limestone}$ | : annual amount of calcic limestone ($CaCO_3$) (t/yr) |
| $M_{Dolomite}$ | : annual amount of dolomite ($CaMg(CO_3)_2$) (t/yr) |
| $EF_{Limestone}$ | : emission factor of calcic limestone ($CaCO_3$) (tC/t) |
| $EF_{Dolomite}$ | : emission factor of dolomite($CaMg(CO_3)_2$) (tC/t) |

- ***Parameters***

- ***Emission factor of calcic limestone ($CaCO_3$)***
  0.120 [tC/t] (default value, GPG-LULUCF)
- ***Emission factor of dolomite($CaMg(CO_3)_2$)***
  0.122 [tC/t] (default value, GPG-LULUCF)

- ***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% respectively 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***

Uncertainties of parameters as well as activity data were assessed individually on the basis of field studies, expert judgment, or default values given in GPG-LULUCF. 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 illustrated 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*

Quality control (QC) is implemented in accordance with the Tier 1 approach described in GPG (2000) and 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*

Recalculations were not applicable, since this subcategory was newly evaluated.

### f) *Source-/Sink-specific Planned Improvements*

None

## 7.13. 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. Biomass burning other than forest fires, such as planned open-air burning, is very rarely carried out in Japan because of heavy restrictions imposed under the "Waste Management and Public Cleansing Law" and the "Fire Defense Law". Hence, $CH_4$, CO, $N_2O$, and NOx emissions derived from biomass burning other than forest fires are reported as "NO". The emission by this subcategory in FY 2007 was 2.1 Gg-$CO_2$; this represents a decrease of 77.0% over the FY 1990 value and a decrease of 21.5% over the FY 2006 value.

### *b*） *Methodological Issues*

● ***Estimation Method***

For $CH_4$, CO, $N_2O$ and NOx emissions due to biomass burning, Tier 1 method is used.

➢ ***Forest land***

($CH_4$、CO)

$$bbGHG_f = L_{forestfires} \times ER$$

($N_2O$、NOx)

$$bbGHG_f = L_{forestfires} \times ER \times N/C$$

$bbGHG_f$ : 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)
$N/C$ : Nitrogen/Carbon ratio

● ***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 GPG-LULUCF, Table 3A.1.15)

➢ ***N/C ratio***

The following values are applied to N/C ratio.
N/C ratio: 0.01 (default value stated in GPG-LULUCF p.3.50)

● ***Activity Data***

➢ ***Forest land***

For activity in Forest land, carbon released by forest fire is used. Carbon released by forest fire is estimated by the Tier 3 method in GPG-LULUCF. For each of national forest land and private forest land, carbon emissions are calculated from the fire-damaged timber volume multiplied by wood density, biomass expansion factor and carbon fraction of dry matter.

$$L_{forestfires} = \Delta C_{fn} + \Delta C_{fp}$$

$L_{forest\ fires}$ : carbon emissions due to fires (tC/yr)
$\Delta C_{fn}$ : carbon emissions due to national forest fires (tC/yr)
$\Delta C_{fP}$ : carbon emissions due to private forest fires (tC/yr)

- ***National forest***

$$\Delta C_{fn} = Vf_n \times D_n \times BEF_n \times CF$$

$\Delta C_{fn}$ : carbon emissions due to national forest fires (tC/yr)
$Vf_{fn}$ : damaged timber volume due to fire in national forest ($m^3$)
$D_n$ : wood density for national forest (t-dm/$m^3$)
$BEF_n$ : biomass expansion factor for national forest
$CF$ : carbon fraction of dry matter (tC/t-dm)

- ***Private forest***

$$\Delta C_{fP} = Vf_p \times D_P \times BEF_P \times CF$$

$\Delta C_{fp}$ : carbon emissions due to private forest fires (tC/yr)
$Vf_p$ : damaged timber volume due to fire in private forest ($m^3$)
$D_p$ : wood density for private forest (t-dm/$m^3$)
$BEF_p$ : biomass expansion factor for private forest
$CF$ : carbon fraction of dry matter (tC/t-dm)

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 forest and semi-natural forests.

Table 7-38 Wood density and biomass expansion factors for national and private forest (FY 2007)

| Type | Wood density [t-dm/$m^3$] | Biomass expansion factor |
|---|---|---|
| National forest | 0.49 | 1.61 |
| Private forest | 0.46 | 1.61 |

Source: Based on Forestry Agency data

Change in biomass due to fires is separately estimated for national forests and private forests respectively.

With regard to national forests, volume of standing timbers damaged due to fires in national forests in *Handbook of Forestry Statistics* is used.

With regard to private forests, damaged timber volume due to fires is estimated by using 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 estimated by multiplying the cumulative volume of age class equal to or under 4 per area estimated by the Survey on Current Status of Forest Resources and the National Forest Resources Database by loss ratio of age class equal to or over 5 in private forests (ratio of damaged timber volume to cumulative volume). The loss ratio is assumed to be constant regardless of age classes.

Table 7-39 Damaged timber volume due to fire in private forest

| Age class | Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| >=5 | Actual damaged area | [ha] | 286 | 943 | 482 | 188 | 146 |
| | Damaged timber volume | [m3] | 47,390 | 58,129 | 54,487 | 17,555 | 11,930 |
| <=4 | Actual damaged area | [ha] | 271 | 506 | 164 | 67 | 140 |
| | Damaged timber volume | [m3] | 14,619 | 9,642 | 5,525 | 1,802 | 3,251 |
| Total damaged timber volume | | [m3] | 62,009 | 67,771 | 60,012 | 19,357 | 15,181 |

Source: Based on Forestry Agency data

Table 7-40 Damaged timber volume due to fire

| | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Damaged timber volume due to fire in national forest | [m3] | 3,688 | 1,014 | 1,599 | 35 | 35 |
| Damaged timber volume due to fire in private forest | [m3] | 62,009 | 67,771 | 60,012 | 19,357 | 15,181 |

### *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 GPG-LULUCF. As a result, the uncertainty estimate for the entire emission by biomass burning was 49%. The methodology of uncertainty assessment is described in Annex 7. In addition, concrete uncertainty estimates for individual parameters in this category will be illustrated in future submissions after investigation is completed.

- ***Time-series Consistency***

Time-series consistency for biomass burning in the Forest Land remaining Forest Land is ensured by using the same data sources (*National Forestry Project Statistics* compiled by the Forestry Agency, and the data provided by the Agency) and the same methodology from 1990 to 2006. In addition, Japan defines the procedure to report information on forest fires in both private and national forests to the Forestry Agency, and the reported data are reflected in the statistics and the data mentioned above. Data from private forest is covering all the forest other than national forest, thus these two sets of data covering all forests in Japan. Therefore, all the emissions resulting from biomass burning in the Forest Land remaining Forest Land are covered in the inventory.

Empirically, burning activities in forests are quite rare since the activities are stringently controlled by the “Waste Management and Public Cleansing Law” and “Fire Defense Law”, and the areas are included in the statistics above.

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

Quality control (QC) is implemented in accordance with the Tier 1 approach described by GPG (2000) and 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*

As a result of review of on-site biomass burning due to the land conversion (Forest land converted to other land-use categories), it is revealed that such a biomass burning is very rarely carried out in Japan because of heavy restrictions imposed under the “Waste Management and Public Cleansing Law” and the “Fire Defense Law”. $CH_4$, CO, $N_2O$, and NOx emissions derived from biomass combustion in relation to land use conversion have accordingly been reported as “NO”.

### *f） Source-/Sink-specific Planned Improvements*

- ***Ratios of incineration of biomass burning and of biomass that remained on the site after biomass burning***

The parameters determined by expert judgment in the 2000 Committee for Greenhouse Gas Emission Estimation Methods were applied to the ratio of incineration of biomass burning and the ratio of biomass that remained on the site after biomass burning. However, there is a need to further examine the parameters to be used. If more accurate and precise data for determining the parameters become available, then recalculations will be implemented for this category.

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# Chapter 8 Waste (CRF Sector 6)

## 8.1. Overview of Sector

In the waste section, GHGs emissions from treatment and disposal of waste are calculated 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 process.

The "waste" to be calculated in the Waste Sector is waste as defined by the Revised 1996 IPCC Guidelines. In addition to municipal and industrial waste defined by the Waste Disposal and Pubic Cleansing Act, waste in Japan for which emissions are calculated includes recyclables and valuables that are re-used within the company. As statistical data relating to waste in Japan are categorized into municipal waste and industrial waste, for many of the emission sources in this sector, estimation methods are discussed separately for municipal and industrial waste.

In 2007, emissions from the waste sector amounted to 24,169 Gg$CO_2$ eq. and represented 1.8% of the Japan's total GHG emissions. The emissions from the waste sector had increased by 7.5% compared to 1990.

In Japan, annual waste generation is amounted to around 600 Mt and has remained unchanged since 1990. According to 2005 data, wastes of biogenic origin, fossil origin, and metal and nonmetallic mineral wastes accounted for 56%, 3% and 41%, respectively. With respect to waste stream for the wastes of biogenic origin, natural decomposition, recycling, volume reduction and final disposal accounted for 25%, 16%, 55% and 4%, respectively. For wastes of fossil origin, recycling, volume reduction and final disposal accounted for 31%, 52% and 18%, respectively. The final disposal amount has been decreasing yearly.

## 8.2. Solid Waste Disposal on Land (6.A.)

This category includes $CH_4$ and $CO_2$ emissions from solid waste disposal on land. The $CO_2$ emissions from this source category are biogenic in origin and therefore, the emissions are not included in national total emissions. Since wastes are classified into municipal and industrial solid waste, category-specific methods were used for emission estimates. Emissions from waste types in Table 8-1 were estimated for solid waste disposal on land.

Emissions of $CH_4$ from composting, which had been reported in the "Solid Waste Disposal on Land (6.A.)" section in previous inventory reports up to the 2008 submission, was moved to the "Other (6.D.)" starting from the 2009 submission of the report.

In 2007, emissions from solid waste disposal on land were 4,518 Gg$CO_2$ eq. and accounted for 0.3% of the national total emissions. The emissions from this source category had decreased by 45.5% compared to 1990.

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[1] The values for some emission sources in the Waste Sector have been complemented by estimation if prior statistical data or related data are not available. The estimation methodology is not discussed in detail in this chapter. For details, refer to "Report of the Waste Panel on Greenhouse Gas Emission Estimate (2006)".

Table 8-1 Categories whose emissions are estimated for solid waste disposal on land (6.A.)

| Category | Waste types estimated | | | Treatment type |
|---|---|---|---|---|
| 6.A.1. (8.2.1) | Municipal solid waste | Kitchen garbage | | Anaerobic landfill |
| | | | | Semi-aerobic landfill |
| | | Waste paper | | Anaerobic landfill |
| | | | | Semi-aerobic landfill |
| | | Waste wood | | Anaerobic landfill |
| | | | | Semi-aerobic landfill |
| | | Waste textiles (natural fiber) [a)] | | Anaerobic landfill |
| | | | | Semi-aerobic landfill |
| | | Sludge | Human waste treatment, Septic tank sludge | Anaerobic landfill |
| | | | | Semi-aerobic landfill |
| | Industrial waste | Kitchen garbage | | Anaerobic landfill [b)] |
| | | Waste paper | | |
| | | Waste wood | | |
| | | Waste textiles (natural fiber) [a)] | | |
| | | Sludge | Sewage sludge | |
| | | | Waterworks sludge | |
| | | | Organic sludge from manufacturing industries | |
| | | | Livestock waste [c)] | |
| 6.A.3. (8.2.3) | Inappropriate disposal [d)] | | | Anaerobic landfill |

a) Only natural fiber waste textiles are included in the estimation under the assumption that synthetic fiber waste is not biologically decomposed in landfills.

b) For landfill disposal of industrial waste, the entire volume is deemed to have been disposed of in an anaerobic landfill because the percentage disposed of in semiaerobic landfill cannot be determined.

c) Although livestock waste is not classified as "sludge" under Japanese law, emissions from it were estimated within the category of sludge because of the similarities in their properties.

d) Illegally dumped waste containing biodegradable carbon is considered to include waste wood, waste paper, and sludge. However, only the emissions from waste wood were calculated, because only its state of dumping is known at present.

### 8.2.1. Emissions from Controlled Landfill Sites (6.A.1.)

#### a) *Source/Sink Category Description*

In Japan, some of the kitchen garbage, waste paper, waste textiles, waste wood, and sludge in municipal solid waste and industrial waste is landfilled without incineration, producing methane when the organic components biodegrade in landfills. Because Japanese landfill sites are appropriately controlled pursuant to the Waste Disposal and Public Cleansing Law, the amount of methane released is counted under "Emissions from Controlled Landfill Sites (6.A.1)." $CO_2$ emission from this source is reported as "NO" because disposed waste is not combusted at the controlled landfill sites in Japan.

#### b) *Methodological Issues*

● ***Estimation Method***

Calculation methods (FOD methods) stipulated in the Revised 1996 IPCC Guidelines and GPG (2000) assume that $CH_4$ emission starts immediately after landfilling of biodegradable waste, but research conducted in Japan has shown that $CH_4$ emissions do not start immediately after landfilling. For this reason, calculation methods based on Japanese research findings were used up to the inventory submitted in 2006. However, because the FOD methods provided in the 2006 IPCC Guidelines were revised to address outstanding issues, we now use an emissions calculation method that complies with the 2006 IPCC Guidelines decision tree (Tier 3) and combines the revised FOD methods with parameters unique to Japan.

$$E = \left\{ \sum \left( EF_{ij} \times A_{ij} \right) - R \right\} \times \left( 1 - OX \right)$$

Where:

$E$ : $CH_4$ emissions from landfills (kg $CH_4$)

$EF_{ij}$ : emission factor of waste i (the amount of $CH_4$ generated by biodegraded waste i of landfill type j

$A_{ij}$ : activity of waste i (amount of waste i biodegraded in the calculated year) of landfill type j

$R$ : amount of recovered landfill $CH_4$ (t)

$OX$ : oxidation factor of $CH_4$ related to soil cover

- ***Emission Factors***

Emission factors were defined as the amount of $CH_4$ (kg) generated through decomposition of one dry ton of unburned biodegradable landfill wastes. The emission factors were set by each type of biodegradable waste and each type of landfill (anaerobic or semi-aerobic landfill). Emission factors were calculated by multiplying each of kitchen garbage, waste paper, waste natural fibers, waste wood, sewage sludge, human waste, waterworks sludge, organic sludge from manufacturing industries and livestock waste by carbon content of biodegraded wastes, disposal site-specific methane correction factor, waste-to-gas conversion rate of landfilled biodegraded waste, and percentages of methane in this landfill gas.

| |
|---|
| Emission factor = (carbon content) × (gas conversion rate) × (methane correction factor) × (percentages of $CH_4$ in landfill gas) ×1000 / 12×16 |

➢ ***Carbon content***

- ***Kitchen garbage, waste paper, waste wood***

Carbon content in each type of waste has been estimated as an average for the all years from 1990 to 2004, by using actual results from the carbon content data in each type of municipal solid waste (MSW) gathered in cities of Tokyo, Yokohama, Kawasaki, Kobe, and Fukuoka. These calculated values are set as uniform percentage of carbon content for each type of waste during the estimation period. Because waste paper, waste textiles and waste wood contained in industrial waste have similar properties to that contained in municipal solid waste (MSW), the same emission factors have been used. There is a case that the properties of kitchen garbage found in industrial waste differ from those of kitchen garbage found in MSW, but because of the difficulty of setting an average for such garbage in the case of industrial waste, where its properties will differ according to industry or place of origin, the emission factor for MSW was used.

- ***Waste natural fiber textiles***

Carbon content of the natural fiber used in textile products was used as the carbon content of waste natural fiber textiles. The carbon content of each natural fiber type (cotton, wool, silk, linen, and recycled textiles) was calculated from the percentage of each fiber type and the carbon content, then this value's weighted average was calculated with each textile's domestic demand to find waste textile carbon content, then an uniform percentage used during estimation period was set by average of each year of carbon content from 1990 to 2004.

- ***Sludge***

The upper limit value of sewage sludge carbon content shown in the *GPG (2000)* was used as the carbon content of sewage sludge. The sewage sludge carbon content was used as the carbon content of sewage treatment and septic tank sludge, and livestock waste treatment. A representative value was selected among data obtained by measurements carried out at several water purification plants as a carbon content of waterworks sludge based on the expert judgment. The carbon content of organic sludge generated by manufacturing industries used here was the value for the papermaking industry, which has the largest final disposal quantity of organic sludge. Because the main constituent of the organic sludge generated by the papermaking industry is paper sludge, we set the carbon content with reference to carbon content of cellulose. The same value is used for every year because it is likely that the properties of sludge do not change much from year to year.

Table 8-2 Carbon content (%) of wastes disposed of in controlled landfill sites

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Kitchen garbage | % | 43.4 | 43.4 | 43.4 | 43.4 | 43.4 |
| Waste paper | % | 40.9 | 40.9 | 40.9 | 40.9 | 40.9 |
| Waste wood | % | 45.2 | 45.2 | 45.2 | 45.2 | 45.2 |
| Waste natural fiber textiles | % | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |
| Sewage sludge | % | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Human waste sludge | % | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Waterworks sludge | % | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Organic sludge from manufacturing | % | 45.0 | 45.0 | 45.0 | 45.0 | 45.0 |
| Livestock waste | % | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |

➢ ***Gas conversion rate***

The rate of conversion to gas from carbon in biodegradable waste in landfill was set at 50%, on the basis of Ito *"A Study on Estimating Amounts of Landfill Gas", Metropolitan Tokyo Sanitation Engineering Journal* No. 18, 1992.

➢ ***Methane correction factor***

These were set to 1.0 for anaerobic landfill sites and 0.5 for semi-aerobic landfill sites using the default values in the *2006 IPCC Guidelines*.

➢ ***Proportions of methane in generated gas***

The default value given in the *Revised 1996 IPCC Guidelines* was used and the proportion of methane was set at 50%.

● ***Activity Data***

Activity data is defined as the amount of waste biodegraded during the calculated year (dry base). The amount of waste i remaining in a landfill in the calculated year (*T*) is the amount determined by adding the amount of waste i landfilled in year *T* to the amount of waste i remaining in year *T–1* multiplied by a certain percentage, while activity is determined by subtracting the amount of waste i remaining in year *T* from the amount of waste i remaining in a landfill in year *T–1*. These data has been calculated for municipal solid waste and industrial waste, type of waste, and type of landfill (anaerobic and semi-aerobic landfill), respectively.

The amount of waste landfilled in each year has been derived by multiplying the volume of biodegradable landfill (volume of landfill by type of waste [wet basis], provided by the Waste Management and Recycling Department, Ministry of the Environment) by the percentage of solids in waste by type of waste. Japan uses 1954 as the starting year in which the former Public Cleansing Law (now the Waste Disposal and Public Cleansing Law) was enacted.

$$W_i(T) = W_i(T-1) \times e^{-k} + w_i(T)$$
$$A_i(T) = W_i(T-1) \times \left(1 - e^{-k}\right)$$
$$k = \ln(2) / H$$

Where:

*Ai(T)* : the amount of waste *i* degraded in the calculated year (year *T*) (activity data: dry base)
*Wi(T)* : the amount of waste *i* remaining in a landfill in year *T*
*wi(T)* : the amount of waste *i* landfilled in year *T*
*k* : decomposition 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）×（percentage of solids in waste *i*）

➢ ***Volume of biodegradable landfill***

- ***Kitchen garbage, waste paper, waste wood***

The amounts of directly landfilled kitchen garbage, waste paper, and waste wood were determined from 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; hereafter, *Cyclical Use of Waste Report*). The amount of municipal solid waste were obtained by multiplying the volume of direct landfill waste for each classification of waste accumulation (by waste type) by the percentages of kitchen garbage, waste paper, and waste wood contained in the volume of direct landfill waste, and added up by the classification of waste accumulation. For the amount of kitchen garbage for industrial waste, sum of the “volume of direct landfill waste” of animal and plant residue and livestock carcasses and “volume of landfill after intermediate processing” of animal and plant residues were used. For the amount of waste paper and waste wood for industrial waste, “the volume of direct landfill waste” was used. Landfilled amounts of both municipal solid waste and industrial waste are determined back to 1980 (some years are interpolated). The 1980 amount is used for years prior to 1980.

- ***Waste natural fiber textiles***

The amount of waste natural fiber textiles directly landfilled was estimated by multiplying the directly landfilled amount of waste textiles, which was determined expediently from the *Cyclical Use of Waste Report*, by the percentages of natural fiber scrap in waste textile. For municipal solid waste, the percentages of natural fiber scrap was set by the percentages of natural fiber in textile products of each year as determined from the *Annual Textile Statistics Report*, and for industrial waste, the percentages of natural fiber scrap in the textile waste was regarded as 100% according to the regulation of the Waste Disposal and Public Cleansing Law that waste textile of ISW does not include synthetic fabrics. The landfill amount in the past year was estimated using the same method used for kitchen garbage, waste paper, waste wood.

- ***Sewage sludge***

Included in the estimation of landfilled sewage sludge amount were the types "raw sludge", "dewatered sludge (dehydrated cake)," "mechanically dried sludge," "concentrated sludge," "dewatering vehicle sludge", "sun-dried sludge", "digested sludge", "screen residue", and "compost" in the sewage treatment plant categories "directly managed" and "disposal by other departments' facilities/public corporations or private sector" as reported in annual editions of *Sewage Statistics (Admin. Ed.)* (Japan Sewage Works Association). Landfilled amounts are determined back to 1985 (some years are estimated). The 1985 amount is used for years prior to 1985.

- ***Human waste treatment, septic tank sludge***

For landfilled amount of human waste treatment and septic tank sludge, we used the amounts given for "direct final disposal" and "final disposal after treatment" of "human waste treatment and septic tank sludge" in annual editions of *Cyclical Use of Waste Repo*rt. The entire amount is considered as the biodegradable landfill amount. Starting with the 2009 inventory report, the activity data for the Final Disposal of Treated Waste has been calculated as a volume that excludes the volume of the final disposal after incineration by waste incineration facilities or sewage treatment facilities.Previous reports up to the 2008 submission used the past data for amounts of treated human waste and septic tank sludge as estimates because data prior to FY1998 could not be extracted directly from statistics. In order to estimate the past final disposal amount more accurately, direct final disposal amount was calculated by multiplying the amount of human waste sludge in landfill (volume-based) reported in the Waste Treatment in Japan (Waste Management and Recycling Department, the Ministry of the Environment) by the weight-conversion factor (1.0 kg/L). The final disposal amount after treatment is estimated by multiplying the estimated direct final disposal amount after treatment by the average ratio of the direct final disposal amount and final disposal amount after treatment.

- ***Waterworks sludge***

The amount of water purification sludge generated and the percentage landfilled were determined from "total amount of soil disposed of" and "landfilled percentage" by each water purification plant given in each year's *Waterworks Statistics* (Japan Water Works Association). Landfill amounts are determined back to 1980. The 1980 amount is used for years prior to 1980.

- ***Organic sludge from manufacturing industries***

Since there are no sources making it possible to determine the total amount of organic sludge landfilled by manufacturing industries year by year, activity data was determined by calculating for "food manufacturing", "papermaking", and "chemicals", industries which landfill large quantities of organic sludge. The amount landfilled by the papermaking industry was determined by using the final disposal amount (dry weight) of organic sludge in *Results of a Study on Industrial Wastes from Paper and Pulp Plants* (Japan Paper Association, Japan Technical Association of the Pulp and Paper Industry, 2006). The landfill amounts for FY1999 and thereafter of the food manufacturing and chemical industries were determined by using *Report on Results of Trend and Industry-Specific Studies on Industrial Wastes (Mining Industry Waste) and Recyclable Waste (2003 Data)* (Clean Japan Center), while the amount for FY1998 and previous years we used *Voluntary Environmental Report (Waste Control Volume), FY2004 Follow-up Results)*. Landfill amounts are determined back to 1990 for "food manufacturing" and "chemicals" and to 1989 for "papermaking". The 1990 amounts are used for years prior to 1990 for "food manufacturing" and "chemicals", 1989 amount is used for years prior to 1990 for "papermaking".

- ***Livestock waste treatment***

The amounts used for the amount of livestock waste treated and landfilled were those given in "direct final disposal" and "final disposal after treatment" of "livestock waste" in annual editions of *Report on the Research on the Wide-range Waste Movement and Control*. Data for 1997 and prior years were set from the "direct final disposal" amount provided every five years by the studies of Waste Management and Recycling Department, Ministry of the Environment for interim years were interpolated from those studies. Landfill amounts are found back to 1980 (some years are interpolated). The 1980 amount is used for years prior to 1980.

➢ ***Percentage of solids in waste***

Percentage of solids in waste was set from the water percentage of each waste type. Table 8-3 shows the percentage of solids in each waste type, and the sources of the figures.

Table 8-3 Percentage of solids in waste disposed of in controlled landfill sites

| Category | Solids (%) | Source |
|---|---|---|
| Kitchen garbage, animal and plant residues | 25 (direct final disposal) | Water percentage of kitchen garbage in *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes* |
| | 30 (final disposal after treatment) | |
| Waste paper | 80 (MSW)<br>85 (ISW) | Expert judgment |
| Waste natural fiber textiles | 80 (MSW)<br>85 (ISW) | Expert judgment |
| Waste wood | 55 | Expert judgment |
| Sewage sludge | Specific to each disposal site | Average moisture content of "delivered or final disposal sludge" in *Sewage Statistics (Admin. Ed.)* |
| Sludge from human waste treatment and septic tanks | 15 (direct final disposal) | Moisture content standard of landfill standard (sludge) specified by enforcement ordinance of Wastes Disposal and Public Cleansing Law |
| | 30 (final disposal after treatment) | Determined by specialists |
| Waterworks Sludge | —※ | — |
| Livestock waste | 16.9 (direct final disposal) | Organic percentage in "*Controlling the Generation of Greenhouse Gases in the Livestock Industry*" |
| | 30 (final disposal after treatment) | Expert judgement |
| Organic sludge from manufacturing industries | 77 (food manufacturing)<br>57 (chemical industries)<br>- (paper industry) | Reference of Clean Japan Center Survey |

※No percentage of solid portion has been established for sludge from water treatment and organic sludge from papermaking because the landfill volumes are calculated on a dry basis..

➢ ***Percentages of landfill sites of each site structure type***

Determining the percentages of municipal solid waste landfill sites of each site structure type involved referring to annual editions of *Results of Study on Municipal Solid Waste Disposal* (Waste Management and Recycling Department, Ministry of the Environment,), which lists Japan's municipal solid waste 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 ($m^3$). However, disposal sites where landfilling started before the 1977 joint order, and all coastal and inland water landfills are treated as anaerobic disposal sites. Additionally, because sites where landfilling started between FY1978 and FY1989 likely include both anaerobic and semi-aerobic sites, we followed the judgment of specialists and calculated the percentage of semi-aerobic sites for years between them by multiplying the landfill volume ($m^3$) of each site by a linearly interpolated correction coefficient. All industrial waste disposal sites are considered to be anaerobic.

Table 8-4 Landfill percentages of municipal solid waste disposal sites by site structure

| Item | Unit | 1977 | 1984 | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Anaerobic landfill percentage | % | 100.0% | 86.1% | 74.2% | 64.2% | 54.4% | 41.8% | 41.8% |
| Semi-aerobic landfill percentage | % | 0.0% | 13.9% | 25.8% | 35.8% | 45.6% | 58.2% | 58.2% |

- ***Decomposition half-life***

Decomposition half-life means the number of years needed for 50% of waste landfilled in a certain year to degrade. According to Ito ("A study on estimating amounts of landfill gas," Metropolitan Tokyo Sanitation Engineering Journal No. 18, 1992), the half-lives of kitchen waste, waste paper, waste natural fiber textiles, and waste wood are, respectively, 3 , 7 , 7 , and 36 year. As we have found no research making it possible to set a half-life for sludge specific to Japan, we use the default value given in the 2006 IPCC Guidelines and set it at 4 year (however, spreadsheets in the *2006 IPCC Guidelines* use 3.7 year, so we set it to 3.7 year).

- ***Delay time***

Delay time means the time lag from the time that the waste is landfilled until decomposition occurs. As we have found no research making it possible to set a delay time specific to Japan, we used the default value given in the 2006 IPCC Guidelines and set it at 6 months.

Table 8-5 Amount of biodegraded waste decomposed in each year (kt)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Kitchen garbage | kt / year (dry) | 517 | 511 | 444 | 264 | 232 |
| Paper | kt / year (dry) | 1,246 | 1,175 | 995 | 754 | 711 |
| Natural fiber | kt / year (dry) | 73 | 65 | 56 | 43 | 41 |
| Wood and bamboo | kt / year (dry) | 344 | 377 | 373 | 353 | 349 |
| Sewage sludge | kt / year (dry) | 297 | 277 | 223 | 130 | 114 |
| Sludge from human waste treatment and septic tank | kt / year (dry) | 111 | 84 | 64 | 51 | 50 |
| Waterworks sludge | kt / year (dry) | 192 | 185 | 157 | 111 | 103 |
| Organic sludge from manufacturing industries | kt / year (dry) | 359 | 288 | 181 | 108 | 99 |
| livestock waste | kt / year (dry) | 251 | 240 | 200 | 230 | 230 |
| Total | kt / year (dry) | 3,391 | 3,203 | 2,693 | 2,042 | 1,928 |

The declining trend of 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***

Landfill $CH_4$ recovery is not particularly common in Japan because, before being landfilled, the waste is subject to treatment and intermediate processing that reduce the amount of organic matter, thus lowering $CH_4$ generation at landfill sites. The amount of $CH_4$ recovered from landfills can only be obtained from the landfill inside the Metropolitan Tokyo Central Breakwater *"Uchigawa-Shobunjo*", where recovered $CH_4$ is used for electric power generation. Thus, the $CH_4$ amount recovered there is accounted for the amount of $CH_4$ recovered from landfills in Japan. There may be some cases of methane recovery at landfill sites other than *Uchigawa-Shobunjo*.

However, these methane recoveries are not included in the estimation because methane recovery at each site is expected to be relatively small in scale.

Because $CO_2$ emitted from the combustion of recovered $CH_4$ is from biomass, and it is not included in the total emissions.

$$R = r \times f \times 16 / 22.4 / 1000$$

r : Amount of recovered landfill gas used for electric power generation in "Uchigawa-Shobunjo" landfill（$m^3N$）
f : Ratio of $CH_4$ to recovered gas（-）

➢ ***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.

➢ ***Ratio of $CH_4$ ratio to the recovered gas***

$CH_4$ ratios were set based on the results of a fact finding survey by the Waste Disposal Management Office of Tokyo because any statistical data concerning the $CH_4$ ratios to recovered landfill gas in the *Uchigawa-Shobunjo* were not available. The $CH_4$ ratio in 1987, when the recovery of landfill gas was started is established as 60%, and the ratio in 1996 is established as 40%. The ratios between 1988 and 1995 were obtained by data interpolation. Data from 1996 was substituted for 1997 and later.

Table 8-6 Recovery amount of $CH_4$ at landfill sites in Japan (Gg $CH_4$)

| Item | Unit | 1987 | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Amount of gaseous use | $km^3N$ | 4,067 | 1,985 | 2,375 | 2,372 | 1,309 | 1,193 |
| $CH_4$ ratio | % | 60.0 | 53.3 | 42.2 | 40.0 | 42.1 | 37.4 |
| Amount of $CH_4$ use | $km^3N$ | 2,440 | 1,059 | 1,003 | 949 | 551 | 446 |
| $CH_4$ unit conversion | Gg $CH_4$ | 1.74 | 0.76 | 0.72 | 0.68 | 0.39 | 0.32 |

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 to soil cover***

Based on law enforcement ordinances and local government ordinances relating to the disposal and cleansing of waste, same-day, intermediate, and final soil covering is practiced at controlled final disposal sites for municipal and industrial solid waste in Japan. As such, the default oxidation factor of 0.1 for controlled landfill sites was used in accordance with the 2006 IPCC Guidelines.

### c) *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The uncertainties in emission factor and activity data were evaluated for each type of waste. The level of uncertainty in emission factors was estimated from a combination of the uncertainties in carbon content, gas conversion rate, methane correction factor, and percentage of methane in generated gas, and estimated to be in the range of 42.4-108.6%. The level of uncertainty in activity data was estimated by combining the uncertainties in the residual amount (landfilled amount and percentage of solids in waste) of biodegradable waste at the end of previous fiscal year of the estimation year and the decomposition rate for the estimation year, and ranged from 31.7% to 56.6%. The level of uncertainty in the emissions from solid waste disposal sites was estimated to be in the range of 53-113%.

The methods of evaluation of the uncertainty levels for each component are:

- Use of 95% confidence interval of actual measurement data: carbon content (kitchen garbage, waste paper and waste wood)
- Use of the statistical uncertainties: domestic demand for textile and landfilled amount of biodegradable waste
- Based on expert judgment: Carbon content (sewage sludge, human waste treatment sludge and organic sludge from manufacturing industries), gas conversion rate, percentage of $CH_4$ in landfill gas and percentage of solids in biodegradable waste
- Use of the default values in the IPCC Guidelines: Carbon content (livestock waste) and methane 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 and default values: Residual amount of biodegradable waste.

For more details about uncertainty estimation methods in Japan, refer to the Annex 7.

- ***Time-series consistency***

Although some activity data since 1990 were not available, data have been estimated through the use of the method described in “Activity data” to develop consistent time-series data. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

### e) *Source-specific Recalculations*

- Because data for waste in landfill, which had remained unchanged due to the unavailability of the most recent data, has been updated, the activity data values for the period from FY2005 to FY2006 were modified and the emissions were recalculated.
- Several data for estimation of emissions have been revised for all years and the emissions were recalculated accordingly.
- In addition to using 0.1 as the value of the oxidation factor, the past data for final disposal of human waste/septic tank sludge was reviewed, and the emissions were recalculated according to the changes in the method of capturing the volume of human waste/septic tank sludge treated and finally disposed of.

**f）** ***Source-specific Planned Improvements***

Further improvements are planned owing to a lack of sufficient current information. Major issues are:
- Gas conversion rate for each type of biodegradable waste
- Carbon content of waterworks sludge
- Country-specific half-life for sludge at final disposal sites
- Percentage of anaerobic and semi-aerobic landfills for industrial solid waste

### 8.2.2. Emissions from Unmanaged Waste Disposal Sites (6.A.2.)

There are no unmanaged waste disposal sites in Japan, because landfill sites in Japan are appropriately controlled pursuant to the Waste Disposal and Public Cleansing Law. Therefore, the emission from this source category is reported as NA.

### 8.2.3. Emissions from Other Controlled Landfill Sites (6.A.3.)

#### 8.2.3.1. Emissions from Inappropriate Disposal (6.A.3.a)

**a）** ***Source/Sink Category Description***

In Japan, waste is disposed of in landfill sites pursuant to the Wastes Disposal and Public Cleansing Law, but a small portion is disposed of illegally. Although this disposal in reality generally satisfies the conditions of controlled disposal sites as defined in the *Revised 1996 IPCC Guidelines*, because it is not appropriate management under the law, methane emissions arising from inappropriate disposal are put under “Other (6.A.3.).” Although rare, fires have been reported at illegal landfill sites, possibly emitting fossil-fuel derived $CO_2$. However, since actual data is not available, the emissions from the fires at illegal landfill sites are reported as “NE”.

**b）** ***Methodological Issues***

- ***Estimation Method***

“Waste wood” and “waste paper” are types of waste which contain biodegradable carbon content and which are inappropriately disposed without incineration, but because the amount of waste paper that remains is very small, only waste wood is estimated.

Just as with emissions from controlled disposal sites (6.A.1.), a FOD method with unique Japanese parameters is used for estimation. Emissions from the part of the wood that is inappropriately disposed of without incineration are estimated by multiplying an emission factor by the amount of wood (dry basis) that degrades in the estimation year.

- ***Emission Factor***

Generally inappropriate disposal in Japan were covered by soil when it was disposed. Thus, the mechanism of $CH_4$ emission from inappropriate disposal is regarded as almost same situation of anaerobic landfill. Therefore the emission factor used is the same as that of anaerobic disposal sites for “waste wood emissions from controlled disposal sites”.

- ***Activity Data***

The residual portion of inappropriately disposed of waste wood is multiplied by the percentage of solids and the decomposition rate to arrive at activity data. The amount of illegally dumped of waste wood is determined from Waste 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). However, because the disaggregated data of the amount of illegal dumping for each discover year cannot be determined, the residual amount of inappropriately disposed waste wood was estimated by discovery year. The percentage of solids and decomposition rate used are the same as those for waste wood that are used in estimating emissions from controlled disposal sites.

Table 8-7 Activity data (kt) of inappropriately disposed of waste wood (dry basis)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Activity data | kt (dry) | 1.4 | 4.7 | 15.2 | 14.8 | 14.2 |

### c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The uncertainties in the emission factor and activity data were evaluated by using the same methods that were 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, refer to the Annex 7.

- ***Time series consistency***

Because data on inappropriate disposal have been available only from 2002, activity data prior to 2002 were obtained by estimation. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

### e) *Source-specific Recalculations*

The emission estimates were recalculated owing to the changes in the residual amount of inappropriate disposal.

### f) *Source-specific Planned Improvements*

No improvements are planned.

## 8.3. Wastewater Handling (6.B.)

The $CH_4$ and $N_2O$ emissions from wastewater handling were estimated. The categories for estimation are shown in Table 8-8. Since wastewater and sludge treatment processes are combined in the emission factors used in Japan, emissions from these processes were also combined for estimation. Therefore, total amount is reported in the subcategory “Wastewater” in CRF 6.B. and the subcategory “Sludge” is reported as IE.

In 2007, emissions from wastewater handling were 2,528 $GgCO_2$ eq. and accounted for 0.2% of the national total emissions. The emissions from this source category had decreased by 25.9% compared to 1990.

Table 8-8 Categories for which wastewater amount is estimated under 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>6.B.1. (8.3.1)</td><td>Industrial wastewater</td><td colspan="2">(Sewage treatment plants)</td><td>○</td><td>○</td></tr>
<tr><td rowspan="16">6.B.2. (8.3.2)</td><td rowspan="11">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><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>

### 8.3.1. Industrial Wastewater (6.B.1.)

#### a) *Source/Sink Category Description*

Industrial effluent generated by factories and other facilities in Japan is treated at those facilities in accordance with regulations based on the Water Pollution Prevention Law and the Sewerage Law. Because methane and nitrous oxide generated in wastewater treatment are usually emitted instead of being recovered, these emissions are counted as "Emissions from industrial wastewater treatment (6.B.1.)"

#### b) *Methodological Issues*

● ***Estimation Method***

The *Good Practice Guidance (2000)* decision tree is followed in estimating methane emissions on a BOD basis and nitrous oxide emissions on a nitrogen basis for industries that have much organic matter in their wastewater. As the default values set in the *Revised 1996 IPCC Guidelines* seem unsuited to Japan's situation, methane emissions were estimated by multiplying the annual amount of organic matter in industrial wastewater (BOD basis)[2] by the emission factor per unit BOD since BOD value is used in effluent regulation in Japan. Because $CH_4$ is emitted in wastewater biological treatment processes, BOD-based activity data (amount of organic matter in wastewater degraded through biological treatement) is thought to be preferable to COD-based data. For this reason, $CH_4$ emissions are calculated in Japan using BOD. Nitrous oxide emissions were estimated by multiplying the amount of nitrogen in industrial wastewater by the emission factor of nitrous oxide generated when treating industrial wastewater.

[2] BOD is used in effluent regulations in Japan. Potassium permanganate ($KMnO_4$) is used for measuring COD in Japan and effectiveness at oxidizing organic compounds is different from commonly-used potassium dichromate ($K_2Cr_2O_7$).

$$E = EF \times A$$

$E$ : 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)

$A$ : organic matter amount (kg BOD) or nitrogen amount (kg N) in industrial wastewater

- ***Emission Factor***

Since amounts of $CH_4$ and $N_2O$ generated from the treatment of industrial wastewater are not known, the emission factors were established by substituting with the emission factors used for the Emissions from Treatment of Domestic and Commercial Wastewater (at sewage treatment plants) (6.B.2.a), which were believed to be relatively similar to the $CH_4$ and $N_2O$ generation processes in wastewater treatment. Since the emission factors used in the Emissions from Treatment of Domestic and Commercial Wastewater (at sewage treatment plants) (6.B.2.a) are expressed in units of volume of wastewater treated ($m^3$), these emission factors were converted to units per amount of organic matter (BOD basis) and nitrogen by dividing the emission factor by the concentrations of organic matter (BOD basis) and nitrogen in the wastewater intake at sewage treatment plants.

The value (180 mg BOD/l) for the BOD concentration of runoff water was obtained from Planned Runoff Water Quality of Municipal Solid Domestic Wastewater in *Guidelines and Explanation of Sewerage Facility Design* (Japan Sewage Works Association, 2001).

The nitrogen concentration of runoff water used was 37.2 mg N/L, which was the simple average of the value for total nitrogen concentration of runoff water of sewage treatment plants, which was found in *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)
＝$8.8 \times 10^{-4}$ (kg $CH_4/m^3$) / 180 (mg BOD/L) × 1000
＝0.00489 ≒ 0.0049 (kg $CH_4$/kg BOD)

*$N_2O$ emission factor*
＝($N_2O$ emission factor for emissions from domestic and commercial wastewater treatment (sewage treatment plant)) / (N concentration in influent water)
＝$1.6 \times 10^{-4}$ (kg $N_2O/m^3$) / 37.2 (mg N/L) × 1000
＝0.0043 (kg $N_2O$/kg N)

- ***Activity Data***

$CH_4$ emission activity data was estimated, with reference to the industries shown in the *Revised 1996 IPCC Guidelines*, by totaling the BOD burdens from industries whose wastewater had high BOD concentrations, and from which large methane emissions arise from treating their wastewater (Table 8-9). BOD concentration by each industrial sub-category was multiplied by the volume of wastewater, and the total of the products was taken as activity data (BOD burden). For industrial sub-categories of which BOD raw water quality by industry wastewater was not provided, activity data was derived by substituting average BOD raw water quality by industry medium category.

> $\underline{CH_4}$ emission activity
> = Σ[(amount of industrial wastewater flowing into wastewater treatment facilities) × (percentage of industrial wastewater treated at treatment facilities emitting $CH_4$) × (percentage of industrial wastewater treated on-site) × (BOD concentration of runoff water)]

For nitrous oxide emission activity data, the amount of nitrogen in the industrial wastewater of each industrial sub-category was determined by taking the amount of wastewater entering wastewater treatment facilities that generate nitrous oxide, and multiplying it by the total nitrogen concentration of the runoff wastewater, which is done for industries whose wastewater contains much nitrogen.

> $\underline{N_2O}$ emission activity
> = Σ[(amount of industrial wastewater flowing into wastewater treatment facilities) × (percentage of industrial wastewater treated at treatment facilities emitting $N_2O$) × (percentage of industrial wastewater treated on-site) × (nitrogen concentration of runoff water)]

➢ ***Amount of industrial wastewater***

The amount of water used for treatment of products, by industrial sub-category, and the volume of water used for washing given in the Ministry of Economy, Trade and Industry's Table of Industrial Statistics - Land and Water were used for the volume of wastewater.

➢ ***Percentage of industrial wastewater treated at facilities generating methane***

Methane arising from industrial wastewater treatment is believed to be generated by the treatment of wastewater with the activated sludge method and by anaerobic treatment. Industrial wastewater treatment percentages for each industry code were 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 each year's Study on the Control of Burdens Generated (Water and Air Environment Bureau, Ministry of the Environment).

➢ ***Percentage of industrial wastewater treated at facilities generating nitrous oxide***

Nitrous oxide arising from industrial wastewater treatment is believed to be generated mainly in biological treatment processes such as denitrification. Data on the fraction of industrial wastewater treated at facilities generating $CH_4$ was used for nitrous oxide emission estimates.

➢ ***Percentage of industrial wastewater treated on-site***

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 concentration for industrial sub-categories we used 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). For nitrogen concentration for industrial sub-categories, the same survey's emission intensities (TN: Total Nitrogen) for industrial sub-categories were used.

Table 8-9 Industries whose activity data were estimated and their BOD burdens (kt BOD/y) (calendar year)

| Industry code | Category of Manufacturing | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| 9 | Food manufacturing | kt BOD | 508.3 | 544.9 | 542.1 | 522.5 | 522.5 |
| 10 | Beverage, tobacco and feeding stuff | kt BOD | 137.9 | 142.7 | 139.0 | 120.0 | 120.0 |
| 11 | Textile manufacturing (excluding clothing material, other textile) | kt BOD | 156.3 | 135.7 | 101.3 | 74.8 | 74.8 |
| 12 | Clothing material and other textile | kt BOD | 3.5 | 4.0 | 2.5 | 1.8 | 1.8 |
| 15 | Pulp, paper and other paper manufacturing | kt BOD | 1,612.4 | 1,505.4 | 1,498.3 | 1,400.8 | 1,400.8 |
| 17 | Chemical industries | kt BOD | 684.1 | 636.5 | 656.9 | 674.2 | 674.2 |
| 18 | Petroleum products and coal product | kt BOD | 3.0 | 2.2 | 2.6 | 2.0 | 2.0 |
| 19 | Plastic products manufacturing | kt BOD | 12.3 | 11.8 | 12.4 | 11.3 | 11.3 |
| 20 | Rubber products manufacturing | kt BOD | 0.9 | 0.9 | 0.6 | 0.7 | 0.7 |
| 21 | Chamois, chamois products and fur skin manufacturing | kt BOD | 5.9 | 5.0 | 3.7 | 2.4 | 2.4 |
| | Total | kt BOD | 3,125 | 2,989 | 2,959 | 2,811 | 2,811 |

* Data for the most recent year are substituted with data from the year immediately preceding.

Sources: Calculated from BOD concentration in *Guidelines and Analysis of Comprehensive Planning Surveys for the Provision of Water Mains, by Catchment Area 1999 Edition* (Japan Sewage Works Association) and volume of wastewater in *Table of Industrial Statistics: Land and Water* (Ministry of Economy, Trade, and Industry).

Table 8-10 BOD (kt BOD) and nitrogen (kt N) amounts in industrial wastewater

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| BOD load | kt BOD | 1,100 | 1,060 | 1,045 | 1,011 | 1,011 |
| TN load | kt N | 91 | 90 | 78 | 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 methane-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 methane, and BOD concentration in runoff water were 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 were estimated to be 71% and 304%, respectively. For details, refer to the Annex 7.

- ***Time-series consistency***

Data on the percentage of industrial wastewater treated at $CH_4$- and $N_2O$-generating facilities since 2001 are available only for 2004. Therefore, data were interpolated and extrapolated for the remaining years. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the

verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e） *Source-specific Recalculations***

The emission estimates were recalculated owing to an update in the amount of wastewater used for 2006.

**f） *Source-specific Planned Improvements***

Since the emission factor for sewage treatment plants has been used for industrial wastewater, a further revision of the emission factor is planned.

### 8.3.2. Domestic and Commercial Wastewater (6.B.2.)

Domestic and commercial wastewater generated in Japan is treated at various kinds of wastewater treatment facilities. Because the methane and nitrous oxide generated in wastewater treatment are usually emitted instead of being recovered, these emissions are counted under "Emissions from treatment of domestic and commercial wastewater (6.B.2.)". Because the methane and nitrous oxide emission characteristics differ from one wastewater treatment facility to another, a different emission calculation method is established for each facility.

The characteristics, effectiveness, and economic efficiency of wastewater treatment systems were thoroughly reviewed, and the most suitable systems were selected for each area in Japan with care also being taken to avoid excessive expenditure. Public sewerage system is spreading from large cities to smaller municipalities and used by 65.5% of the population. 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 2006, septic tanks (*jokasou*) were used by 24.1% 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).

#### 8.3.2.1. Sewage Treatment Plant (6.B.2.a)

**a） *Source/Sink Category Description***

This category includes $CH_4$ and $N_2O$ emissions from treatment of wastewater at sewage treatment plants.

**b） *Methodological Issues***

- ***Estimation Method***

Emissions of methane and nitrous oxide from this source have been calculated using Japan's country-specific method, in accordance with Decision Tree of the *Good Practice Guidance (2000)* (Page 5.14, Fig. 5.2). Emissions were derived by multiplying the volume of sewage treated at sewage treatment plants by the emission factor (Refer to *6B-2006.xls¥6B2-D&C* for details of the calculation process).

$$E = EF \times A$$

*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***

Emission factors were established by adding the simple averages for each treatment process, having taken the actual volume of methane and nitrous oxide released from sludge treatment and water treatment processes measured at sewage treatment plants from research studies conducted in Japan. (Water treatment process: 528.7 [mg $CH_4/m^3$], 160.3 [mg $N_2O/m^3$]; sludge treatment process: 348.0 [mg $CH_4/m^3$], 0.6 [mg $N_2O/m^3$])。

*Calculation of methane emission factor*

= Average of emission factor for water treatment processes
+ Average of emission factor for sludge treatment processes
= 528.7 [mg $CH_4/m^3$] ＋ 348.0 [mg $CH_4/m^3$]
= $8.764 \times 10^{-4}$ [kg $CH_4/m^3$]

*Calculation of nitrous oxide emission factor*

= Average of emission factor for water treatment processes
+ Average of emission factor for sludge treatment processes
= 160.3 [mg $N_2O/m^3$] ＋ 0.6 [mg $N_2O/m^3$]
= $1.609 \times 10^{-4}$ [kg $N_2O/m^3$]

- ***Activity Data***

Activity data for methane and nitrous oxide emissions associated with water treatment at sewage treatment plants was derived by subtracting the volumes subject to primary processing from the annual volume of water treated, as given in the Japan Sewage Works Association Sewage Statistics (Admin. Ed.).

In order to avoid overestimates of activity data, volumes subject to primary processing was subtracted from the annual volume of water treated because methane and nitrous oxide emitted from this source are primarily emitted from biological reaction tanks although the annual volume of water treated as given in the Sewage Statistics (Admin. Ed) includes primary treatment volumes that are only subject to settling.

Activity data: sewage treatment plant
= (Annual volume of water treated at sewage treatment plants)
− (Annual input volume for primary processing at sewage treatment plants)

Table 8-11 Activity data (sewage treatment plant)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Annual amount of wastewater | $10^6 m^3$ | 9,857 | 10,392 | 12,519 | 13,591 | 13,591 |

### c） *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The uncertainties in $CH_4$ and $N_2O$ emission factors were estimated by using the 95% confidence interval of actual measurement data. The uncertainty in activity data was 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 were estimated to be 33% and 146%, respectively. For details, refer to the Annex 7.

- ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

### e） *Source-specific Recalculations*

The emission estimates were recalculated owing to an update in activity data for 2006.

### f） *Source-specific Planned Improvements*

A revision of the emission factor for sewage treatment plants is planned owing to the high uncertainty.

## 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. This category includes $CH_4$ and $N_2O$ emissions from domestic sewage treatment plants. Emissions from human waste within its residence time in vault toilets were accounted for under this category, whereas the emissions that occur after the waste is collected from vault toilets were accounted for under “Human waste treatment facilities” (6.B.2.c).

### b） *Methodological Issues*

- ***Estimation Method***

Methane and nitrous oxide emitted from this source were calculated using Japan’s country-specific method, in accordance with Decision Tree the Good Practice Guidance (2000) (Page 5.14, Fig. 5.2). Emissions were derived by multiplying the annual population of treatment for each type of domestic sewage treatment plant by the emission factor (Refer to 6B-2006.xls¥6B2-D&C for details of the calculation process).

$$E = \sum \left( EF_i \times A_i \right)$$

$E$ : 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)

$A$ : Population (persons) requiring waste processing at domestic sewage treatment plant *i* per year

- ***Emission Factors***

Emission factors for methane and nitrous oxide have been established by each type of domestic sewage treatment plants, including community plants, *gappei*-shori johkasou, *tandoku*-shori johkasou, and vault toilets. (Table 8-12, Table 8-13).

Table 8-12 Methane emission factor for domestic sewage treatment plants

| Domestic wastewater treatment facilities | Methane emission factor [kg $CH_4$/person-year] |
|---|---|
| Community plants[a] | 0.195 |
| *Gappei*-shori johkasou[a] | 1.106 |
| *Tandoku*-shori johkasou[b] | 0.197 |
| Vault toilets[c] | 0.197 |

a: Masaru Tanaka, *Compendium of Waste,* Maruzen 1998

b: Uses averages of actual measurements given in Takeishi, Suzuki, and Matsubara *B-2(7) Research to Reveal Emission Volumes from Sewage Treatment Plants* FY1993 and FY1994 Global Environment Research Fund Outcome Report

c: Assumed to be same as for isolation type *tandoku*-shori johkasou

Table 8-13 Nitrous oxide emission factor for domestic sewage treatment plant

| Domestic wastewater treatment facilities | Nitrous oxide emission factor [kg $N_2O$/person-year] |
|---|---|
| Community plants [a] | 0.0394 |
| *Gappei-shori johkasou*[a] | 0.0264 |
| *Tandoku-shori johkasou*[b] | 0.0200 |
| Vault toilets [c] | 0.0200 |

a: Uses averages of actual measurements given in Tanaka, Inoue, Matsuzawa, Osako, and Watanabe *B-2(1) Research into Volumes Released from Waste Treatment Plants* 1994 Global Environment Research Fund Outcome Report[1)]

b: Uses averages of actual measurements given in 1) and Takeishi, Suzuki, and Matsubara, *B-2(7) Research to Reveal Emission Volumes from Sewage Treatment Plants* FY1993 and FY1994 Global Environment Research Fund Outcome Report

c: Assumed to be same as for isolation type *tandoku*-shori johkasou

- ***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*, was used as the activity data for methane and nitrous oxide emitted in association with domestic wastewater treatment facilities.

Table 8-14 Annual treatment population by type of domestic sewage treatment plant (1,000 persons)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Gappei-shori | 1000 person | 7,983 | 8,515 | 10,806 | 13,286 | 13,286 |
| Tandoku-shori | 1000 person | 25,119 | 26,105 | 23,289 | 17,187 | 17,187 |
| Vault toilet | 1000 person | 38,920 | 29,409 | 20,358 | 12,983 | 12,983 |
| Community plant | 1000 person | 493 | 398 | 414 | 361 | 361 |
| Total | 1000 person | 72,515 | 64,427 | 54,867 | 43,817 | 43,817 |

**c） *Uncertainties and Time-series Consistency***

● ***Uncertainties***

The level of uncertainty in the emission factor was evaluated for each treatment facility taking into account the actual measurement data and setting methods. The following data were 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 was 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) were estimated to be 87% and 72%, respectively. For details, refer to the Annex 7.

● ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e） *Source-specific Recalculations***

The emission estimates were recalculated owing to an update in activity data for 2006.

**f） *Source-specific Planned Improvements***

No improvements are planned.

### 8.3.2.3. Human-Waste Treatment Plant (6.B.2.-)

**a） *Source/Sink Category Description***

This category includes the emissions of $CH_4$ and $N_2O$ 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***

Methane emitted from this source has been calculated using Japan's country-specific methodology, in accordance with Decision Tree of the Good Practice Guidance (2000) (Page 5.14, Fig. 5.2). Emissions were calculated by multiplying the volume of domestic wastewater treated at human waste treatment plants, by the emission factor (Refer to 6B-2006.xls¥6B2-D&C for details of the calculation process).

$$E = \sum \left( EF_i \times A_i \right)$$

$E$ : 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***

Methane emission factors were 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.

Table 8-15 Methane emission factors by each treatment process

| Treatment method | Methane emission factor [kg $CH_4/m^3$] |
|---|---|
| Anaerobic treatment [a] | 0.543 |
| Aerobic treatment [b] | 0.00545 |
| Standard de-nitrification treatment [c] | 0.0059 |
| High load de-nitrification treatment [c] | 0.005 |
| Membrane separation [d] | 0.00545 |
| Other [d] | 0.00545 |

a: Actual methane emissions given in the Japan Environmental Sanitation Center *Report of Analytical Survey of Methane Emissions FY1989 Commissioned by the Environmental Agency* multiplied by the rate of recovery of 1-methane (90%).

b: Actual data on emissions is not available. A simple average of standard- and high-load de-nitrification has been used.

c: Tanaka, Inoue, Matsuzawa, Osako, and Watanabe *B-2(1) Research into Volumes Released from Waste Treatment Plants* FY1994 Global Environment Research Fund Outcome Report

d: Actual data on emissions is not available. The emission factor for aerobic treatment has been substituted.

- ***Activity Data***

Activity data for methane emissions associated with the processing of wastewater at human waste treatment plants was determined from the calculated throughput volume for each of the treatment processes (Table 8-18), by multiplying the total volume of human waste and septic tank sludge processed at human waste treatment plants that were indicated in *Waste Treatment in Japan* (Table 8-16) by the capacity of each treatment process (Table 8-17).

Table 8-16 Volume of human waste treated at their treatment plants

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Vault toilet | 1000 kl/year | 20,406 | 18,049 | 14,673 | 9,864 | 9,864 |
| ST sludge | 1000 kl/year | 9,224 | 11,545 | 13,234 | 14,089 | 14,089 |
| Total | 1000 kl/year | 29,630 | 29,594 | 27,907 | 23,953 | 23,953 |

Data from *Waste Treatment in Japan*

Table 8-17 Trends in treatment capacity by treatment process

| Unit | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Anaerobic treatment | kl/day | 34,580 | 19,869 | 10,996 | 5,856 | 5,856 |
| Aerobic treatment | kl/day | 26,654 | 19,716 | 12,166 | 8,005 | 8,005 |
| Standard denitrification | kl/day | 25,196 | 30,157 | 31,908 | 28,363 | 28,363 |
| High-intensity denitrification | kl/day | 8,158 | 13,817 | 16,498 | 15,980 | 15,980 |
| Membrane separation | kl/day | 0 | 1,616 | 2,375 | 4,264 | 4,264 |
| Other | kl/day | 13,777 | 20,028 | 25,917 | 34,733 | 34,733 |

Table 8-18 Activity Data

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Anaerobic treatment | 1000 kl/year | 9,455 | 5,589 | 3,073 | 1,443 | 1,443 |
| Aerobic treatment | 1000 kl/year | 7,288 | 5,546 | 3,400 | 1,973 | 1,973 |
| Standard denitrification | 1000 kl/year | 6,889 | 8,483 | 8,917 | 6,989 | 6,989 |
| High-intensity denitrification | 1000 kl/year | 2,231 | 3,887 | 4,611 | 3,938 | 3,938 |
| Membrane separation | 1000 kl/year | 0 | 455 | 664 | 1,051 | 1,051 |
| Other | 1000 kl/year | 3,767 | 5,634 | 7,243 | 8,559 | 8,559 |
| Total | 1000 kl/year | 29,630 | 29,594 | 27,907 | 23,953 | 23,953 |

### 2） $N_2O$

#### ● *Estimation Method*

Nitrous oxide emitted from this source has been calculated using Japan's country-specific methodology, in accordance with Decision Tree of the Good Practice Guidance (2000) (Page 5.14, Fig. 5.2). Emissions were calculated by multiplying the volume of nitrogen treated at human waste treatment plants, by the emission factor (Refer to 6B-2006.xls¥6B2-D&C for details of the calculation process).

$$E = \sum \left( EF_i \times A_i \right)$$

$E$ : Emission of nitrous oxide from the processing of domestic and commercial wastewater at 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 waste treatment plants (by treatment process *i*) (kg N)

#### ● *Emission factors*

Emission factor for nitrous oxide was determined for each of the various treatment processes, including high-load denitrification treatment and membrane separation systems using the results of actual case studies in Japan.

Table 8-19 Nitrous oxide emission factors by each treatment process

| Treatment method | $N_2O$ emission factors [kg $N_2O$-N/kg-N] | | |
|---|---|---|---|
| | FY1990-1994 | FY1995-2002 | FY2003 - |
| high load de-nitrification treatment | 0.033[a] | Calculated by interpolation using the values of FY1994 and FY 2003 | 0.0029[b] |
| membrane separation | 0.033[a] | Calculated by interpolation using the values of FY1994 and FY 2003 | 0.0024 |
| Other (including anaerobic treatment, aerobic treatment, standard de-nitrification treatment) | 0.0000045[c*] | | |

a : Use median value of actual measurements at 13 plants given in Tanaka, Inoue, Osako, Yamada, and Watanabe *B-16(7) Research into Limiting Generation of Methane and Nitrous Oxide from the Waste Sector* FY1997 Global Environment Research Fund Outcome Report

b : Use median value of actual measurements at 13 plants given in Omura, Kawakubo, and Yamada. *Study of Emission Factors for $N_2O$ from High-load Human Waste Management.* Journal of Waste Management, 57 (260).

c : Tanaka, Inoue, Matsuzawa, Osako, and Watanabe *B-2(1) Research into Volumes Released from Waste Treatment Plants* FY1994 Global Environment Research Fund Outcome Report

* : Calculated by dividing upper limit value for standard de-nitrification treatment (0.00001kg $N_2O/m^3$) by treated nitrogen concentration in FY1994 (2,211mg/L).

● ***Activity Data***

The volume of nitrogen treated at human waste treatment plants is calculated by multiplying treated nitrogen concentration by the volume of human waste treated at these facilities (the sum of collected human waste and sewage in sewerage tank), given in 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:***

Refer to the data used for the calculation of methane emissions from human waste treatment plants (Table 8-16 ).

➢ ***Percentage throughput of the human waste treatment processes:***

Refer to the data used for the calculation of methane emission from human waste treatment plants (Table 8-17).

➢ ***Nitrogen concentration in human waste and septic tank sludge input at treatment plants:***

See Table 8-20.

Table 8-20 Concentration of nitrogen contained in collected human waste and sewage in sewerage tank

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Vault toilet | mg N/l | 3,940 | 3,100 | 2,700 | 2,700 | 2,700 |
| ST sludge | mg N/l | 1,060 | 300 | 580 | 580 | 580 |
| Weighted average | mg N/l | 3,043 | 2,008 | 1,695 | 1,453 | 1,453 |

Use analytical values for FY 1989-1991, FY1992-1994, FY1995-1997 and FY1998-2000.

Data after 2001 are replaced by that in 2000.

Source: Okazaki, Shimizu, and Morita. *Study of Operation Records Based on Precision Function Inspection of Human Waste Management Plant.* Japan Environmental Sanitation Center Report, 28.

Table 8-21 Activity data: Amount of nitrogen in human waste and septic tank sludge processed at human waste treatment plants

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Anaerobic treatment | kt N | 28.8 | 11.2 | 5.2 | 2.1 | 2.1 |
| Aerobic treatment | kt N | 22.2 | 11.1 | 5.8 | 2.9 | 2.9 |
| Standard denitrification | kt N | 21.0 | 17.0 | 15.1 | 10.2 | 10.2 |
| High-intensity | kt N | 6.8 | 7.8 | 7.8 | 5.7 | 5.7 |
| Membrane separation | kt N | 0.0 | 0.9 | 1.1 | 1.5 | 1.5 |
| Other | kt N | 11.5 | 11.3 | 12.3 | 12.4 | 12.4 |
| Total | kt N | 90.2 | 59.4 | 47.3 | 34.8 | 34.8 |

### c) *Uncertainties and Time-series Consistency*

#### ● *Uncertainties*

The level of uncertainty in the $CH_4$ emission factor was 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 were estimated by using the statistical uncertainties. The uncertainty level in $N_2O$ emission factors was also evaluated by treatment type. For high-intensity denitrification and membrane separation, the 95% confidence interval of actual measurement data on emission factors was used. For other treatments, the default values set by the Committee for GHGs Emissions Estimation Methods were used. The uncertainty in activity data for $N_2O$ was 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 were estimated to be 101% and 106%, respectively. For details, refer to the Annex 7.

#### ● *Time series consistency*

For $N_2O$ emission factor, consistent data over the time series were constructed based on the actual measurement data by using the methods described in Table 8-19. For other parameters, data were constructed consistently for the entire time series. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the

verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e)** ***Source-specific Recalculations***

The emission estimates were recalculated owing to an update in activity data for 2006.

**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 domestic wastewater thus disposed of decomposes naturally and emits methane and nitrous oxide. The amounts of methane and nitrous oxide emitted from this source are reported in the Emissions from Processing of Domestic and Commercial Wastewater (6.B.2.).

**b)** ***Methodological Issues***

- ***Estimation Method***

The calculation method was 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 methane were zero. Accordingly, methane emissions were calculated by multiplying the volume of organic matter contained in the untreated domestic wastewater that was discharged into public waters by the emission factor. The nitrous oxide emission was 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 were determined in accordance with the 2006 IPCC Guidelines. The emission factor for methane was established by multiplying the maximum methane generation potential by a methane correction factor (MCF). The maximum methane generation potential was set to 0.6 kg $CH_4$/kg BOD, given in the 2006 IPCC Guidelines, and the MCF was set to 0.1, a default value for "Sea, river and lake discharge" of "Untreated systems". The emission factor for nitrous oxide was calculated from the value of 0.005 kg $N_2O$-N/kg N after conversion of the units.

Table 8-22 $CH_4$ and $N_2O$ emission factors for decomposition of domestic wastewater in nature

| |
|---|
| 0.06 kg $CH_4$/kg BOD |
| 0.0079 kg $N_2O$/kg N |

### ● *Activity Data*

Activity data were calculated for the categories of "domestic wastewater from households using tandoku-shori johkasou (a system developed in Japan for on-site treatment of human waste only) and vault toilets", "domestic wastewater from households using on-site disposal systems", "human waste and septic tank sludge dumped into ocean" and sewage sludge dumped into ocean (from 2009 submission), by the following method:

Table 8-23 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 [a)] | 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 – *Waste Treatment in Japan*

Unit BOD and unit nitrogen from domestic wastewater – *1999 Survey of Comprehensive Sewerage System Development Program by Watershed – Guidelines and Commentaries*

BOD concentration and nitrogen concentration in human waste and septic tank sludge: Okazaki, Shimizu, and Morita. Study of Operation Records Based on Precision Function Inspection of Human Waste Management Plant. Japan Environmental Sanitation Center Report, 28

a) 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 8-24 Activity data: Emission from natural decomposition of domestic wastewater

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Tandoku-shori johkasou | kt BOD | 366.7 | 381.1 | 341.0 | 250.9 | 250.9 |
| Vault toilet | kt BOD | 568.2 | 429.4 | 298.0 | 189.6 | 189.6 |
| On-site disposal | kt BOD | 46.2 | 21.0 | 9.4 | 3.2 | 3.2 |
| Ocean dumping (Human waste) | kt BOD | 21.7 | 13.5 | 9.3 | 2.2 | 2.2 |
| Ocean dumping (sewage sludge) | kt BOD | 0.8 | 0.9 | 0.0 | 0.0 | 0.0 |
| Total | kt BOD | 1,002.9 | 845.1 | 657.7 | 445.9 | 445.9 |

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Tandoku-shori johkasou | kt N | 18.3 | 19.1 | 17.0 | 12.5 | 12.5 |
| Vault toilet | kt N | 28.4 | 21.5 | 14.9 | 9.5 | 9.5 |
| On-site disposal | kt N | 2.3 | 1.1 | 0.5 | 0.2 | 0.2 |
| Ocean dumping (Human waste) | kt N | 7.2 | 3.2 | 2.2 | 0.5 | 0.5 |
| Ocean dumping (sewage sludge) | kt N | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Total | kt N | 56.3 | 44.7 | 34.6 | 22.7 | 22.7 |

### 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 methane generation potential and the methane 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 were 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 methane generation potential and methane 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 were estimated to be 76%. For more details, refer to the Annex 7.

- ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

### e) *Source-specific Recalculations*

-The emissions were recalculated owing to an update in data for 2006.

-Emissions from sewage sludge dumped into the ocean was newly added to the estimates. It should be noted, however, that the emissions were calculated only for the period from FY1990 to FY2003 as a result of the ban on ocean dumping of the sewage sludge by law in FY2004.

### f) *Source-specific Planned Improvements*

No improvements are planned.

## 8.3.2.5. Recovery of $CH_4$ emitted from treating domestic and commercial wastewater (6.B.2.-)

### a) *Source/Sink Category Description*

When treating domestic and commercial wastewater in Japan, the methane generated by fermentation of sludge in sewage treatment plants and human waste treatment facilities is thought to be recovered, but due to the lack of statistics making it possible to determine the amount of methane recovered at human waste treatment facilities, the amount of methane recovered at sewage treatment plants is calculated and reported as the recovered amount of $CH_4$ generated in the treatment of domestic and commercial wastewater.

The GPG (2000) suggests a method which calculates $CH_4$ emissions by deducting the amount of recovered $CH_4$ from the $CH_4$ generated from treatment of domestic and commercial wastewater. In Japan, the amount of recovered $CH_4$ is not used in the calculation of the $CH_4$ emissions since the emission factors used to calculate the emissions of $CH_4$ from domestic and commercial wastewater treatment facilities are based on actual measurements. Accordingly, the amount of recovered of $CH_4$ is reported as a reference.

### b) *Methodological Issues*

#### ● *Estimation Method*

The amount of methane recovered from sludge digesters at sewage treatment plants is calculated by multiplying the amount of digester gas recovered from digesters by an emission factor that takes into account the concentration of methane in digester gas.

#### ● *Emission factors*

The emission factor is set by finding the weight equivalent of the average methane concentration in digester gas.

$$EF = F_{CH_4} \times 16/22.4$$

$F_{CH4}$ : concentration of methane in digester gas (volumetric base)

The $CH_4$ concentration in digester gas (volumetric base) was 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 methane recovered from sewage treatment plant sludge digesters is determined from "amount of digester gas generated by sludge treatment facilities" in Sewerage Statistics, Administrative Volume, Japan Sewerage Works Association. Because all the digester gas generated at Japanese sewage treatment plants 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 that is 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 Sewerage Statistics.

Table 8-25 Amount of methane recovered from sewage treatment plant sludge digesters (Gg $CH_4$)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Recovered $CH_4$ amount | Gg $CH_4$ | 88.7 | 110.5 | 113.3 | 130.2 | 130.2 |
| Portion used as energy | Gg $CH_4$ | 65.3 | 73.9 | 75.3 | 90.6 | 90.6 |

### c) *Uncertainties and Time-series Consistency*

#### ● *Uncertainties*

The uncertainty analysis has not been conducted because the amount of $CH_4$ recovered is reported as a reference value.

- ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

No recalculations were performed.

**f) *Source-specific Planned Improvements***

No improvements are planned.

## 8.4. Waste Incineration (6.C.)

Japan uses incinerators to reduce the volume of waste. Emissions of carbon dioxide, methane, and nitrous oxide from the incineration of thewastes are estimated in this category. Starting with the 2009 inventory report, the following reporting categories which fall under the "Emissions from Waste Used as Energy and the Incineration of Waste Accompanied by Energy Recovery" are moved from Incineration of Waste (Category 6.C.) to Fuel Combustion (Category 1.A.) in accordance with the Revised 1996 IPCC Guidelines and GPG (2000).

- Emissions from the Incineration of Waste in Which Energy is Recovered
- Emissions from Waste Used Directly as Fuel
- Emissions from Fuel Made from Waste

Accordingly, the emissions reported under the Incineration of Waste (Category 6.C.) are the emissions from the incineration without recovery of energy (simple incineration). Reporting categories for the calculation of emissions from the incineration of waste are summarized in Table 8-26.
As the Revised 1996 IPCC Guidelines stipulate that the concept for the emission factors and estimation methods used in the Waste Incineration (Category 6.C.) should be same as that applied to the calculation of emissions from the incineration of waste used as energy and that from which energy is recovered, and that it is desirable to estimate emissions in a consistent manner regardless of whether energy is used or not in order to prevent duplication or omission of the emissions, the description of the methods of estimating emissions is included in the Incineration of Waste (Category 6.C.) as was the case in the past.

In 2007, emissions from waste incineration were 16,533 $GgCO_2$ eq. and accounted for 1.2% of the national total emissions. The emissions from this source category had increased by 20.6% compared to 1990.

For reference, the FY2007 emission amount reported in Incineration of Waste (Category 6.C.) was 30,769 $GgCO_2$ when it included the emissions from the incineration of waste used as energy and the waste incinerated for recovery of energy calculated in the same manner as in the Japanese inventories up to the 2008 submission, accounting for 2.2% of the total greenhouse gas emissions in Japan, an increase of 41.5% from the emissions in FY1990.

Table 8-26 Categories for the calculation of emissions from waste incineration (6.C.)

| Incineration | Waste category | Estimation classification | Category of estimation | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|
| Waste incineration (without energy recovery) | Municipal solid waste | Plastic | 6.C.1 | ○ | ○ Estimated in bulk | ○ Estimated in bulk |
| | | Synthetic textile | 6.C.1 | ○ | | |
| | | Other (biogenic)[a)] | 6.C.1 | | | |
| | Indsutrial solid waste | Waste oil | 6.C.2 | ○ | ○ | ○ |
| | | Waste plastic | 6.C.2 | ○ | ○ | ○ |
| | | Other (biogenic)[a)] | 6.C.2 | | ○ | ○ |
| | Specially controlled industrial waste | Waste oil | 6.C.3 | ○ | ○ | ○ |
| | | Infectious waste (plastic) | 6.C.3 | ○ | ○ | ○ |
| | | Infectious waste (except plastic) [a)] | 6.C.3 | | ○ | ○ |
| Waste incineration with energy recovery | Municipal solid waste | Plastic | 1.A.1 | ○ | ○ Estimated in bulk | ○ Estimated in bulk |
| | | Synthetic textile | 1.A.1 | ○ | | |
| | | Other (biogenic) [a)] | 1.A.1 | | | |
| | Industrial solid waste | Waste oil | 1.A.1 | ○ | ○ | ○ |
| | | Waste plastic | 1.A.1 | ○ | ○ | ○ |
| | | Other (biogenic) [a)] | 1.A.1 | | ○ | ○ |
| Direct use of waste as fuel | Municipal solid waste | Plastic | 1.A.1/2 | ○ | ○ | ○ |
| | Industrial solid waste | Waste oil | 1.A.2 | ○ | ○ | ○ |
| | | Waste plastic | 1.A.2 | ○ | ○ | ○ |
| | | Waste wood | 1.A.2 | | ○ | ○ |
| | Waste tire | Fossil origin | 1.A.1/2 | ○ | ○ | ○ |
| | | Biogenic origin | 1.A.1/2 | | | |
| Use of waste processed as fuel | Refuse derived fuel (RDF・RPF) | Fossil origin | 1.A.2 | ○ | ○ | ○ |
| | | Biogenic origin | 1.A.2 | | | |

a) The $CO_2$ emissions from the incineration of biomass-derived waste 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.

Table 8-27 GHG emissions from incineration of waste (Category 6.C.) (2007 FY)

| Incineration type | Waste category | Estimation classification | Unit | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|
| Waste incineration (without energy recovery) | Municipal solid waste | Plastics | Gg $CO_2$ | 3154.5 | 5.1 | 242.0 |
| | | Synthetic textile | Gg $CO_2$ | 455.4 | | |
| | | Other (biogenic)[a)] | Gg $CO_2$ | | | |
| | Industrial solid waste | Waste oil | Gg $CO_2$ | 4440.7 | 0.2 | 5.6 |
| | | Waste plastic | Gg $CO_2$ | 4284.6 | 1.1 | 93.5 |
| | | Other (biogenic)[a)] | Gg $CO_2$ | | 3.2 | 1942.3 |
| | Specially-controlled waste | Waste oil | Gg $CO_2$ | 1458.9 | 0.1 | 1.8 |
| | | Infectious waste plastics | Gg $CO_2$ | 432.6 | 0.1 | 9.4 |
| | | Infectious waste (except plastics) | Gg $CO_2$ | | 0.1 | 1.5 |
| Total | | | Gg $CO_2$ | 14226.6 | 9.8 | 2296.1 |

Table 8-28 Total GHG emissions from incineration of waste (reference value) (2007 FY)
Emissions including emissions from incineration of waste for energy use and energy recovery

| Incineration type | Waste category | Estimation classification | Unit | $CO_2$ | $CH_4$ | $N_2O$ |
|---|---|---|---|---|---|---|
| Waste incineration (without energy recovery) | Municipal solid waste | Plastics | Gg $CO_2$ | 3154.5 | 5.1 | 242.0 |
| | | Synthetic textile | Gg $CO_2$ | 455.4 | | |
| | | Other (biogenic)[a] | Gg $CO_2$ | | | |
| | Industrial solid waste | Waste oil | Gg $CO_2$ | 4440.7 | 0.2 | 5.6 |
| | | Waste plastic | Gg $CO_2$ | 4284.6 | 1.1 | 93.5 |
| | | Other (biogenic)[a] | Gg $CO_2$ | | 3.2 | 1942.3 |
| | Specially-controlled waste | Waste oil | Gg $CO_2$ | 1458.9 | 0.1 | 1.8 |
| | | Infectious waste plastics | Gg $CO_2$ | 432.6 | 0.1 | 9.4 |
| | | Infectious waste (except plastics) | Gg $CO_2$ | | 0.1 | 1.5 |
| Waste incineration with energy recovery | Municipal solid waste | Plastics | Gg $CO_2$ | 6660.0 | 10.8 | 510.8 |
| | | Synthetic textile | Gg $CO_2$ | 961.4 | | |
| | | Other (biogenic)[a] | Gg $CO_2$ | | | |
| | Industrial solid waste | Waste oil | Gg $CO_2$ | 112.9 | 0.0 | 0.1 |
| | | Waste plastics | Gg $CO_2$ | 332.1 | 0.1 | 7.2 |
| | | Other (biogenic)[a] | Gg $CO_2$ | | 0.1 | 35.4 |
| Direct use of waste as fuel | Municipal solid waste | Plastics | Gg $CO_2$ | 446.1 | 0.0 | 0.0 |
| | Industrial solid waste | Waste oil | Gg $CO_2$ | 3808.9 | 0.6 | 13.8 |
| | | Waste plastics | Gg $CO_2$ | 1329.2 | 3.3 | 4.3 |
| | | Waste wood | Gg $CO_2$ | | 69.8 | 11.7 |
| | Waste tire | Fossil origin | Gg $CO_2$ | 992.7 | 0.9 | 3.4 |
| | | Biogenic origin | Gg $CO_2$ | | | |
| Use of waste processed as fuel | Refuse-derived fuel (RDF, RPF) | Fossil origin | Gg $CO_2$ | 1339.6 | 0.1 | 7.7 |
| | | Biogenic origin | Gg $CO_2$ | | | |
| Total | | | Gg $CO_2$ | 30209.3 | 95.4 | 2890.5 |

## 8.4.1. Waste Incineration Without Energy Recovery (Simple Incineration) (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 municipal solid waste. Because municipal solid waste contains both biogenic and non-biogenic waste, methane and nitrous oxide emissions are estimated as the total that includes biogenic waste, and is reported in the "Plastic and other non-biogenic waste" category. The methane and nitrous oxide emissions from the incineration of industrial waste are reported in either the "biogenic" or "plastics and other non-biogenic waste" category, depending on the type of waste.

#### b) *Methodological Issues*

##### *1) $CO_2$*

- ***Estimation Method***

Emissions of carbon dioxide from this source has been calculated by using Japan's country-specific emission factors, the volume of waste incinerated (dry basis) and percentage of municipal waste incinerated at the municipal incineration facilities which recover energy, in accordance with the Decision Tree of the Good Practice Guidance (2000) (Page 5.26, Fig. 5.5). Emissions from plastics and synthetic textile scraps in municipal waste were estimated for the estimation of $CO_2$ emissions from the incineration of fossil-fuel-derived waste[3].

$$E = EF \times A \times (1 - R)$$

*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 base) (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***

Based on the approach taken by the Revised 1996 IPCC Guidelines, the emission factor for this source was calculated by multiplying the carbon content of each type of waste by the rate of combustion at each incinerator.

<u>*$CO_2$ emission factor (dry basis)*</u>
= 1000 [kg] × Carbon content × Rate of combustion × 44/12

➢ ***Carbon content***

The carbon content in waste plastics has been estimated for relevant year as an average using actual results from the data gathered cities of Tokyo, Yokohama, Kawasaki, Kobe and Fukuoka; calculate a moving average of the carbon content for each type of waste over a five-year period, centered around the relevant year, for each municipal government; and convert it to a weighted average using the population of each municipality.

For the carbon content of synthetic textile scraps contained in municipal solid waste, the carbon content of the synthetic fibers in the textile products was used, with the average content calculated from the molecular formulas of polymers for each type of synthetic textile weighted by the volume of synthetic textile consumption.

➢ ***Incineration rate***

Considering Japan's circumstances, the maximum default value of 99% given in the Good Practice Guidance (2000) has been used for incineration rate of waste plastics.

Table 8-29 Carbon content of plastics and synthetic textile scrap in MSW

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Plastics | % | 72.0 | 73.4 | 74.2 | 76.4 | 76.2 |
| Synthetic textile | % | 63.0 | 63.0 | 63.0 | 63.0 | 63.0 |

- ***Activity data***

[3] Emissions from the incineration of kitchen garbage, waste paper, waste natural fiber textiles and waste wood were 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 plastics and synthetic textile scraps.

Activity data for carbon dioxide emission from the incineration of waste plastics in municipal solid waste was calculated by multiplying the volume of plastics incinerated by the percentage of solid plastics. Similarly, activity data for synthetic textile scraps was calculated by multiplying the incinerated volume of textile scraps in municipal solid waste by the percentage of solids in textile scraps and the percentage of synthetic fibers in the textile scraps.

> *Activity data for incineration of plastics (MSW) (dry basis)*
> = Volume of plastics incinerated × percentage of solid plastics content

> *Activity data for incineration of synthetic textile scraps (MSW) (dry basis)*
> = Volume of textile scraps incinerated × percentage of solid content in textile scraps × percentage of synthetic fiber content in textile scraps

➢ ***Incineration volume by type of municipal solid waste***

The values were extracted from the Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes.

➢ ***Percentage of solid content***

The percentage of solid plastics contained in municipal solid waste was calculated to be 80% using the water content (20%) indicated in the Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes. The percentage of solid content in the textile scraps contained in municipal solid waste was calculated to be 80% using the water content (20%) determined by specialists on the basis of existing studies in Japan.

➢ ***Percentage of synthetic textile scraps in textile scraps***

The percentage of synthetic textile scrap content in textile scraps contained in the municipal solid waste was calculated using the percentage of synthetic textile products in textile products, which was determined using the ratio of the demand for synthetic textile to the demand for all textiles in Japan for each year for which the data were available in the Textile Statistics Yearbooks.

Table 8-30 Incineration of plastics and synthetic textile scraps (MSW)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Plastics | kt / year (dry) | 3,998 | 4,160 | 4,919 | 3,548 | 3,548 |
| Synthetic textile | kt / year (dry) | 476 | 531 | 473 | 602 | 620 |

○ Percentage of municipal waste incinerated at municipal incineration facilities for energy recovery

The percentage of municipal waste that is incinerated at municipal incineration facilities from which energy is recovered is the percentage of municipal waste incinerated at municipal incineration facilities which supply electricity or heat outside them. The value was obtained from the State of Municipal Waste Treatment Survey (Ministry of the Environment).

Table 8-31 Percentage of municipal solid waste incinerated at incineration facilities with energy recovery

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Without off-field power generation or heat utilization | % | 46.3 | 44.4 | 38.9 | 32.1 | 32.1 |
| With off-field power generation or heat utilization | % | 53.7 | 55.6 | 61.1 | 67.9 | 67.9 |

### 2） $CH_4$

● ***Estimation Method***

$CH_4$ emissions from the incineration of municipal waste were calculated by taking the amount of incinerated municipal waste by incinerator type (emission basis) and multiplying by the emission factor established for each type, and then multiplying the result by the percentage of municipal waste incinerated in energy-recovering municipal incinerators.

$$E = \sum (EF_i \times A_i) \times (1 - R)$$

$E$ : Emission of methane from the incineration of the municipal solid waste (kg $CH_4$)
$EF_i$ : Emission factor for incineration method $i$ for municipal solid waste (wet basis) (kg $CH_4$/t)
$A_i$ : Volume of municipal solid waste incinerated by method $i$ (wet basis) (t)
R : Percentage of municipal solid waste incinerated at facilities with energy recovery

- ***Emission factor***

The emission factor for methane from this source was determined for individual facilities according to the actual measurement data of the methane concentration in flue gas from the facilities. The emission factors were not adjusted for atmospheric concentration of methane. A weighted average was estimated using the volume of incineration from each facility, to obtain emission factors by both type of furnace and by type of facility; and calculate a weighted average using the number of facilities with stoker and fluid bed furnaces, to obtain emission factors by types of incineration facility.

Table 8-32 $CH_4$ emission factors, by type of incineration facility, for municipal solid waste

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Continuous incinerator | g $CH_4$/t | 8.2 | 8.2 | 8.3 | 8.4 | 8.4 |
| Semi-continuous incinerator | g $CH_4$/t | 69.6 | 69.6 | 75.1 | 87.0 | 87.0 |
| Batch type incinerator | g $CH_4$/t | 80.5 | 80.5 | 84.1 | 86.8 | 86.8 |

Source: Measurement surveys (Environmental Agency *Results of Review of Calculation of Emissions of Greenhouse Gas Part 2* (2000))
Iwasaki, Tatsuichi, Ueno *Review of Causes of Emissions of Nitrous Oxide and Methane from Waste Incinerators* (1992) Annual Report of the Tokyo Metropolitan Research Institute for Environmental Protection
Japan Society of Atmospheric Environment *Method of Estimating Greenhouse Gas Emissions – Survey Report* (1996)
Waste Management and Recycling Department , Ministry of the Environment, *Japan's Waste Disposal* （CD-ROM）
Ishikawa Prefecture, City of Osaka, Kanagawa Prefecture, City of Kyoto, City of Kobe, Niigata Prefecture, Hiroshima Prefecture, Hyogo Prefecture, Fukuoka Prefecture, Hokkaido *Survey of Compilation of Emission Units of Greenhouse Gas from Stationary Sources* (1991-1997)

- ***Activity Data***

Volume of material incinerated by type of incineration facility has been used as the activity data for methane emissions associated with the incineration of municipal solid waste.

The method for calculating the relevant activity data was to multiply the volume of municipal solid waste incinerated, given in the Waste Management and Recycling Department , Ministry of the Environment *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes (the Volume on Cyclical Use*), by the proportion of incineration for each type of facility for incinerating municipal solid waste, from the Waste Management and Recycling Department , Ministry of the Environment, *Waste Treatment in Japan.*

Table 8-33 Amount of incineration by type of incineration facility for MSW

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Continuous incinerator | kt /year (wet) | 26,215 | 29,716 | 32,729 | 34,893 | 34,893 |
| Semi-Continuous Incinerator | kt /year (wet) | 4,810 | 5,455 | 5,813 | 3,881 | 3,881 |
| Batch type Incinerator | kt /year (wet) | 5,643 | 4,328 | 3,094 | 1,478 | 1,478 |

### 3） $N_2O$

- ***Estimation Method***

Emissions of nitrous oxide from the incineration of municipal solid waste were determined in accordance with the Decision Tree in the Good Practice Guidance (2000) (Page 5.27, Fig. 5.6). Specifically, the emissions were calculated by multiplying the volume of the municipal solid waste incinerated (wet basis) by Japan's country-specific emission factor that was determined from the nitrous oxide concentration of flue gas from the incinerators of municipal solid waste and by the percentage of municipal solid waste incinerated at incineration facilities with energy recovery.

***Emission factor***

Emission factors for nitrous oxide were calculated for individual incineration facilities based on the actual measurement data of nitrous oxide concentration in flue gas from these facilities. Emission factors were established for each type of incinerator by using the same weighted average method used for determining the methane emission factors.

Table 8-34 $N_2O$ emission factors by type of facility for incinerating municipal solid wastes

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Continuous incinerator | g $N_2O$/t | 58.8 | 58.8 | 59.1 | 59.8 | 59.8 |
| Semi-continuous incinerator | g $N_2O$/t | 56.8 | 56.8 | 57.3 | 58.4 | 58.4 |
| Batch type Incinerator | g $N_2O$/t | 71.4 | 71.4 | 74.8 | 77.3 | 77.3 |

Source: Measurement surveys (Environmental Agency Results of Review of Calculation of Emissions ofGreenhouse Gas Part 2 (2000))
Iwasaki, Tatsuichi, Ueno *Review of Causes of Emissions of Nitrous Oxide and Methane from Waste Incinerators* (1992) Annual Report of the Tokyo Metropolitan Research Institute for Environmental Protection
Japan Society of Atmospheric Environment Method of Estimating Greenhouse Gas Emissions – Survey Report (1996)
Waste Management and Recycling Department, Ministry of the Environment *Japan's Waste Disposal* （CD-ROM）
Ishikawa Prefecture, City of Osaka, Kanagawa Prefecture, City of Kyoto, City of Kobe, Niigata Prefecture, Hiroshima Prefecture, Hyogo Prefecture, Fukuoka Prefecture, Hokkaido *Survey of Compilation of Emission Units of Greenhouse Gas from Stationary Sources* (1991-1997)

- ***Activity Data***

The volume of material incinerated by type of incineration facility was used as the activity data for nitrous oxide emitted in association with incineration of municipal solid waste, as for methane emissions.

## c） *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of uncertainty in the $CO_2$ emission factor was estimated by using the uncertainties in the carbon content of municipal solid waste (plastic and synthetic textile) and the combustion rate of municipal solid waste incineration facilities. The uncertainty in activity data for $CO_2$ emissions was estimated from the uncertainties in the incinerated amount of municipal solid waste, percentage of solids and fraction of synthetic textile (for synthetic textile in municipal solid waste).

The uncertainties in the $CH_4$ and $N_2O$ emission factors were 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 were estimated by using the uncertainties in the incinerated amount 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 solids
- 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 municipal solid waste were estimated to be 17% and 23%, respectively. The uncertainties in the $CH_4$ and $N_2O$ emissions from incineration of municipal solid waste were estimated to be 101% and 42%, respectively. For more details, refer to the Annex 7.

- ***Time-series consistency***

Because data on the incinerated amount by type of waste were not available for years prior to 1997, the data were estimated by using the total incinerated amount of municipal solid waste for each year and the ratio of incinerated amount by waste type for 1998. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

### e） *Source-specific Recalculations*

- The calculation method was changed to report the emissions from municipal waste incineration where energy is recovered in the Fuel Combustion (Category 1.A.) in accordance with the Revised 1996 IPCC Guidelines. Only the emissions from the non-energy recovering waste incineration (simple incineration) is reported in the Waste Incineration (Category 6.C.) section. This change affects the reporting categories only, and does not change the total emissions in Japan.

-The estimates were recalculated because activity data were updated for 2005-2006.

### f） *Source-specific Planned Improvements*

No improvements are planned.

### 8.4.1.2. Industrial Waste Incineration (6.C.2)

**a) *Source/Sink Category Description***

In this category, $CO_2$, $CH_4$ and $N_2O$ emissions from incineration of industrial solid waste are estimated by each waste type and reported in the corresponding category either “biogenic” or “plastics and other non-biogenic waste”.

**b) *Methodological Issues***

***1) $CO_2$***

- ***Estimation Method***

Emissions of carbon dioxide from this source have been calculated using the volume of waste oil and waste plastics incinerated, and Japan’s country-specific emission factor, in accordance with Decision Tree of the Good Practice Guidance (2000) (Page 5.26, Fig. 5.5). Since industrial waste textile does not include synthetic fabrics scrap under the regulation of the Waste Disposal and Public Cleansing Law, industrial waste textile is regarded as waste natural fiber. Thus the $CO_2$ emissions from incineration of industrial waste textile are not included in national total because of the emissions are from biogenic source.

$$E = EF \times A \times (1 - R)$$

$E$ : 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, an emission factor was calculated by multiplying the carbon content of each type of waste by the rate of combustion at incineration facilities.

| |
|---|
| Carbon dioxide emission factor<br>= 1000 [kg] × Carbon content × rate of combustion × 44/12 |

➢ ***Carbon content***

The carbon content in waste oil has been deemed to be 80%, from the factor of 0.8 (t C/t) given in the Environmental Agency’s Report on a Survey of Carbon Dioxide Emissions (1992).
The carbon content in waste plastic has been deemed to be 70%, from the factor of 0.7 (t C/t) given in the Environmental Agency’s Report on a Survey of Carbon Dioxide Emissions (1992).

➢ ***Rate of combustion***

In light of the actual situation of emissions in Japan, the rate of combustion in facilities for the incineration of waste oil and waste plastics from fossil fuels was deemed to be 99.5% on the basis of the maximum default value for dangerous wastes given in the Good Practice Guidance.

- ***Activity Data***

The volume of waste oil and plastics in industrial waste that was incinerated was used unchanged for the activity data for the carbon dioxide emissions from the incineration of the waste in these categories used in the Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes. Waste oil was deemed to be entirely derived from fossil fuel.

| |
|---|
| *Activity data for the incineration of waste oil and plastics (ISW) (wet basis)*<br>= Volume of waste oil and plastics incinerated |

Table 8-35 Incinerated ISW (waste oil and waste plastics)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Waste oil | kt / year (wet) | 1,299 | 1,567 | 1,749 | 1,560 | 1,560 |
| Waste plastics | kt / year (wet) | 842 | 1,794 | 1,780 | 1,808 | 1,808 |

The State of the Industrial Waste Discharge and Disposal Survey used as the source data in the Report on the Survey of Cyclic Use, from which the activity data was sourced, is a statistical survey carried out under the Statistics Act. The survey estimates the emissions based on data relating to the discharge and disposal of industrial waste reported by prefectural governments to the Ministry of the Environment by making adjustments with respect to survey years and to sectors that are not surveyed. Questionnaires sent to the prefectural governments are divided into "Industrial Waste (including specially controlled industrial waste)" and "Specially controlled Industrial Waste (contained in the total industrial waste)". The former is used for summation. Accordingly, the statistical values included in the Report on Discharge and Disposal of Industrial Waste (Ministry of the Environment, Waste Management and Recycling Division), which is published every year, contain portions of the specially controlled industrial waste contained in the industrial waste. This indicates that the inventory reports up to the 2008 submission were double counting the emissions from the incineration of specially controlled industrial waste. In order to eliminate this duplication, the activity data was re-calculated by reducing the value of the activity data for "emissions from the incineration of industrial waste" (amount of incinerated industrial waste) by the amount of incinerated specially controlled industrial waste, and "emissions from the incineration of industrial waste" was recalculated. The calculation assumed that the waste oil in the specially controlled industrial waste was included in Waste Oil, plastics within the infectious waste in the specially controlled industrial waste was included in Waste Plastics, and the remainder of the infectious waste was included in "waste paper or wood waste".

○ Percentage of industrial waste incinerated at industrial incineration facilities which recover energy (by type)

The percentage of industrial waste that is incinerated at industrial incineration facilities from which energy is recovered is the percentage of industrial waste incinerated at the industrial incineration facilities which supply electricity or heat outside them. The value was obtained from the FY2007 Survey of Industrial Waste Treatment Facilities (Ministry of the Environment). In Japan, industrial incinerators are installed mainly by private sector waste disposal enterprises. In comparison with the municipal waste incinerators installed primarily by municipal governments, efforts to recover energy (for use in power generation and as a heat source) are in their infancy. Accordingly, the percentage is smaller in the industrial waste category.

Table 8-36 Percentage of industrial solid waste incinerated at incineration facilities with energy recovery

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Waste oil | % | 0.6 | 0.7 | 0.6 | 2.5 | 2.5 |
| Waste plastics | % | 1.4 | 1.4 | 4.1 | 7.2 | 7.2 |
| Waste wood | % | 0.2 | 0.8 | 1.1 | 1.8 | 1.8 |
| Sludge (including sewage sludge | % | 0.9 | 0.8 | 1.0 | 1.6 | 1.6 |
| Sewage sludge | % | 0.2 | 0.8 | 1.1 | 1.8 | 1.8 |
| Other | % | 0.2 | 0.8 | 1.1 | 1.8 | 1.8 |

### 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)
$R$ : Percentage of industrial solid waste $j$ incinerated at facilities with energy recovery

- ***Emission factor***

Emission factors were calculated for individual incineration facilities based on the existing survey data of the methane concentration in flue gas. No adjustments were made for the atmospheric methane drawn into the facilities. The calculation of the emission factors used a weighted average of volumes by type of industrial waste incinerated at each facility.

Table 8-37 Methane emission factors for type of industrial waste

| Type of waste | Emission factor [g $CH_4$ / t] | Remarks |
|---|---|---|
| Paper or wood scraps | 0.022 | Weighted average of data from 5 facilities |
| Waste oil | 0.0048 | Weighted average of data from 5 facilities |
| Waste plastics | 0.030 | Weighted average of data from 4 facilities |
| Sludge | 0.014 | Weighted average of data from 19 facilities |

Sources: Measurement surveys (Environmental Agency Results of Review of Calculation of Emissions of Greenhouse Gas Part 2 (2000))
Japan Society of Atmospheric Environment Method of Estimating Greenhouse Gas Emissions – Survey Report (1996)
Ishikawa Prefecture, City of Osaka, Kanagawa Prefecture, City of Kyoto, Hiroshima Prefecture, Hyogo Prefecture, Survey of Compilation of Emission Units of Greenhouse Gas from Stationary Sources (1991-1999)

• For textile scraps and animal and plant residues or animal carcasses, the emission factors for paper or wood scraps were used.

- ***Activity Data***

The incinerated volume (wet basis) for each type of waste was used for the determination of activity data for methane emissions from the incineration of industrial waste.

- ***Paper and wood scraps, waste oil, textile scraps, animal and plant residues or animal carcasses:***

The incinerated volume was extracted from the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes* for each type.

- ***Sludge***

Activity data was taken as the aggregate of the values extracted 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 and Waste plastics***

The activity data determined for carbon dioxide emission from the types of waste oil and waste plastics in industrial waste was used.

Table 8-38 Incinerated ISW, by waste types

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Waste paper, waste wood | kt / year (wet) | 3,014 | 5,455 | 3,832 | 2,187 | 2,187 |
| Sludge | kt / year (wet) | 5,032 | 5,850 | 6,371 | 7,149 | 7,149 |
| Waste textile | kt / year (wet) | 31 | 49 | 50 | 43 | 43 |
| Plant residues or animal carcasses | kt / year (wet) | 77 | 125 | 272 | 167 | 167 |

### 3） $N_2O$

- ***Estimation Method***

Nitrous oxide emissions from this source were calculated by multiplying the incinerated volume of the industrial waste by Japan's country-specific emission factor and by percentage of industrial solid waste incinerated at incineration facilities with energy recovery. For sewage sludge, a separate emission factor was calculated for each type of flocculant and incinerator used, and where high-molecular-weight flocculants and fluidized-bed incinerators were used, separate emission factors were calculated for different combustion temperatures

- ***Emission factor***
- ***Waste other than sewage sludge***

Emission factors were calculated in Japan using the nitrous oxide concentration in flue gas based on existing survey data. No adjustments were made for atmospheric nitrous oxide drawn into incineration facilities. The final emission factors were calculated for each type of industrial waste using the weighted average of volumes incinerated at individual incineration facilities. It should be noted that the value for paper and wood scraps were used as a substitute for the values for textile scraps and animal and plant residues or animal carcasses.

$$ef_{i,j} = \frac{M_{i,j} \times G_{i,j} \times 1000 \times 44}{I_{i,j} \times 22.4}$$

$M_{i,j}$ : Average nitrous oxide concentration in flue gas at incineration facility *j* that incinerates industrial waste *i* (ppm)

$G_{i,j}$ : Dry volume of flue gas from incineration facility *j* that incinerated industrial waste *i* at the time of nitrous oxide concentration measurement ($m^3$N/h)

Table 8-39 Emission factor for nitrous oxide, by type of industrial waste

| Type of industrial waste | Emission factor（g-$N_2O$/t） |
|---|---|
| Waste Paper, Waste Wood | 20.92 |
| Waste Oil | 11.83 |
| Waste Plastics | 179.75 |
| Sludge | 456.22 |

The same emission factors are applied every year.

Source: Measurement surveys (Environment Agency Results of Review of Calculation of Emissions of Greenhouse Gas Part 2 (2000))

Japan Society of Atmospheric Environment Method of Estimating Greenhouse Gas Emissions – Survey Report (1996)

Ueno, et al. *Review of Measures to Reduce Nitrous Oxide in Sewage Treatment Plants* Tokyo Metropolitan Research Institute for Environmental Protection (1995)

Nakamura, et al. *Emission of Nitrous Oxide from Incineration of Sewage Sludge* Proceedings of the 20th Japan Urban Cleaning Research Conference pp. 391–393 (1998)

Yasuda, et al. *Behavior of Nitrous Oxide Emissions Associated With Incineration of Sewage Sludge* Journal of Japan Society of Waste Management Experts Vol. 5, No. 4, (1994)

Matsubara and Mizuochi *Survey of Emissions of Nitrous Oxide from Sewage Treatment Plants* Environmental and Sanitary Engineering Research, 8(3) (1994)

Suzuki, Ochi, Miyata *Continuous Measurement of Nitrous Oxide Emissions from Sewage Sludge Flux Furnaces* Proceedings of the 11th Environmental Engineering Symposium 2001, pp. 387–390（2001）

Takeishi, Watanabe, Matsubara, Hirayama, Maebashi, Koma, Wakasugi, and Yoshikawa *Report on Joint Research into the Behavior and Reduction of Waste Gas Components in Flux Furnaces* Public Works Research Institute, Ministry of Construction and Nagoya City Water Authority（1996）

Takeishi, Watanabe, Matsubara, Sato, Maebashi, Tanaka, Miwa, Wakasugi, and Yamashita *Report on Joint Research into the Behavior and Reduction of Waste Gas Components in Flux Furnaces* Public Works Research Institute, Ministry of Construction and Nagoya City Water Authority（1994）

Ishikawa Prefecture, City of Osaka, Kanagawa Prefecture, City of Kyoto, Hiroshima Prefecture, Hyogo Prefecture, *Survey of Compilation of Emission Units of Greenhouse Gas from Stationary Sources* (1991-1999)

- ***Sewage sludge***

Emission factors for nitrous oxide from sewage sludge were calculated based on the actual measurement data. Specifically, the calculation weighted the average emission factor for each incineration facility by the volume of sewage sludge incinerated at the facility. As the emission factors vary depending on types of flocculants or incinerators used and the temperatures inside incinerators, the emission factors were determined separately for the categories shown in Table 8-40.

Table 8-40 Nitrous oxide emission factor for sewage sludge incineration

| Type of flocculant | Type of incinerator | Combustion Temperature | Emission Factor ($g N_2O/t$) |
|---|---|---|---|
| High-molecular-weight flocculant | Fluidized Bed Incinerator | Normal temperature combustion (around 800℃) | 1,508 |
| | Fluidized Bed Incinerator | High temperature combustion (around 850℃) | 645 |
| | Multiple Hearth | — | 882 |
| Other | — | — | |
| Lime Sludge | — | — | 294 |

Assume that emission factors for FY1990-2002 are constant.

Source: Matsubara and Mizuochi, Survey of Emissions of Nitrous Oxide from Sewage Treatment Plants Environmental and Sanitary Engineering Research, 8(3) (1994)

Public Works Research Institute, Ministry of Construction and Nagoya City Water Authority, Report on Joint Research into the Behavior and Reduction of Waste Gas Components in Flux Furnaces (1994)

Public Works Research Institute, Ministry of Construction and Nagoya City Water Authority, Report on Joint Research into the Behavior and Reduction of Waste Gas Components in Flux Furnaces (1996)

Nakamura, et al. Emission of Nitrous Oxide from Incineration of Sewage Sludge Proceedings of the 20th Japan Urban Cleaning Research Conference pp. 391–393 (1998)

- ***Activity Data***

➢ ***Industrial waste other than sewage sludge***

Activity data (wet basis) was determined in the same manner as for the methane emissions from industrial waste with the exception that the “volume of other incinerated organic sludge” was used as activity data for the sludge (excluding sewage sludge).

➢ ***Sewage sludge***

The values in the “volume of incinerated sewage sludge, by flocculants and by incinerator types” reported in Sewage Statistics (Admin. Ed.) (Japan Sewage Works Association), were used for activity data (wet basis) for this source.

Table 8-41 Activity data for nitrous oxide emissions from incineration of sewage sludge

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| High-molecular-weight flocculant | kt / year (wet) | 1,112 | 1,869 | 2,397 | 2,474 | 2,474 |
| High-molecular-weight flocculant | kt / year (wet) | 128 | 219 | 723 | 1,781 | 1,781 |
| High-molecular-weight flocculant | kt / year (wet) | 560 | 656 | 572 | 88 | 88 |
| Lime sludge | kt / year (wet) | 1,070 | 767 | 341 | 219 | 219 |
| Other | kt / year (wet) | 190 | 316 | 267 | 299 | 299 |

### c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The uncertainties in the $CO_2$ emission factor and activity data for waste oil and waste plastics were evaluated by the same method as was used for incineration of municipal solid waste. The uncertainties in $CH_4$ and $N_2O$ emission factors were estimated by using the 95% confidence interval of actual measurement data of the emission factors by type of industrial solid waste and by type of incineration facility. The uncertainties in the $CH_4$ and $N_2O$ activity data were 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 were estimated to be 150% and 116%, respectively. The uncertainties in the $CO_2$ emissions from incineration of waste oil and waste plastics were 105% and 100%, respectively. For more details, refer to the Annex 7.

- ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e）** ***Source-specific Recalculations***

- The estimation method was changed so that emissions from industrial waste incineration where energy is recovered are reported in Fuel Combustion (Category 1.A.) in accordance with the Revised 1996 IPCC Guidelines. Only the emissions from the non-energy recovering waste incineration (simple incineration) are reported in Waste Incineration (Category 6.C.). This change affects the reporting categories only, and does not change the total emissions in Japan.

-The activity data in both 8.4.1.2 Incineration of Industrial Waste and in 8.4.2.2 Incineration of Industrial Waste with Energy Recovery contained the amounts of incinerated specially controlled industrial waste used for the calculation of emissions in 8.4.1.3 Incineration of Specially Controlled Industrial Waste. The duplication was eliminated by deducting the incinerated amount of specially controlled industrial waste from the amount of incinerated industrial waste, and the emissions from FY1990 and onward were recalculated.

- The emission estimates were recalculated owing to an update in activity data for 2006.

**f）** ***Source-specific Planned Improvements***

A further improvement is planned for estimates owing to a lack of sufficient current information on the percentage of incinerated amount of waste oil of biogenic origin.

### 8.4.1.3. Incineration of Specially controlled Industrial Waste (6.C.3)

**a）** ***Source/Sink Category Description***

In this category, the $CO_2$, $CH_4$, and $N_2O$ emissions from incineration of specially controlled industrial waste were estimated by each waste type and reported in the corresponding category either “biogenic” or “plastics and other non-biogenic waste”. Based on law enforcement ordinances related to the disposal and cleansing of waste, PCB waste must be treated by high-temperature incineration or other methods stipulated by the Ministry of the Environment (chemical degradation methods or removal methods involving cleasing and separation), but since the base year (FY1990), PCBs have not been incinerated, and chemical degradation has been used. Oil resulting from PCB waste degradation treatment is treated as ordinary industrial waste if it meets requirements, and is incinerated or used in thermal recycling. These amounts are thought to be included in waste oil listed in the “Industrial Waste Generation and Treatment Survey” , Waste Management and Recycling Department, Ministry of the Environment, which means that the GHG emissions generated are already reported in “Incineration of industrial waste (8.4.1.2)”. As such, to avoid duplicated entry, emissions from PCB waste treatment are not included in this category.

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 carbon dioxide from the incineration of waste oil and infectious plastic waste contained in specially controlled industrial waste were calculated in accordance with the Decision Tree included in the Good Practice Guidance (2000) (Page 5.26, Fig 5.5) using Japan's country-specific emission factors and the incinerated volume.

- ***Emission factor***

The emission factors for waste oil and plastics in industrial waste were used as the emission factor for waste oil and plastics in specially controlled industrial waste as it was believed that there was little difference between them in terms of carbon contents and rates of combustion.

- ***Activity Data***

On the assumption that the entire volume of waste oil and infectious plastic waste contained in specially controlled industrial waste was incinerated, carbon emission activity data was calculated using the output volume of the 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) for the waste oil. For the plastics in infectious waste, the activity data was 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.

| |
|---|
| *Activity data for incineration of waste oil (specially controlled ISW) (wet basis)*<br>= Output volume of waste oil |

| |
|---|
| *Activity data for incineration of plastics in infectious waste (specially controlled ISW)(wet basis)*<br>= Output volume of infectious waste × percentage of plastic content in infectious waste |

#### *2） $CH_4$*

- ***Estimation Method***

Emissions of methane from the incineration of waste categorized as "waste oil" and "infectious waste" of specially controlled industrial waste were 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 were not available, the emission factors for the incineration of industrial waste were used as substitutes for determining the emission factor for each type of specially controlled industrial waste. Specifically, the substitute emission factors used were the waste oil in industrial waste for the waste oil; the waste plastics in industrial waste for the infectious waste plastics; and paper and wood scraps in industrial waste for non-plastic infectious waste.

- ***Activity Data***

Activity data for the waste oil and infectious waste plastics were calculated using the same values as those used in the calculation of activity data associated with carbon dioxide emission. The volume of non-infectious waste 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 nitrous oxides from the incineration of the waste oil and infectious waste in specially controlled industrial waste were 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 were not available, the nitrous oxide emission factors for the incineration of industrial waste were used as substitutes for determining the emission factor for each type of specially controlled industrial waste. Specifically, the substitute emission factors used were the waste oil in industrial waste for the waste oil; the waste plastics in industrial waste for the infectious waste plastics; and the paper and wood scraps in industrial waste for non-plastic infectious wastes.

- ***Activity Data***

Activity data was calculated by using the same values used in the calculation of activity data associated with methane emissions.

Table 8-42 Incineration of specially controlled industrial waste

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Waste oil | kt (wet) | 256 | 380 | 560 | 500 | 500 |
| Infections Waste (plastic) | kt (wet) | 78 | 128 | 167 | 169 | 169 |
| Infections Waste (non-plastic) | kt (wet) | 105 | 172 | 225 | 228 | 228 |

## c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The values for industrial solid waste were applied for the uncertainties in $CO_2$, $CH_4$ and $N_2O$ emission factors. The uncertainties in activity data were evaluated separately for waste oil and waste plastics. For the incinerated amount of waste oil and infectious waste, twice the statistical uncertainties were applied. For waste plastics, the uncertainties in the percentage of plastics in infectious waste (expert judgment) and incinerated amount were used. The uncertainties in the $CO_2$, $CH_4$ and $N_2O$ emissions from incineration of specially controlled industrial waste were estimated to be 167%, 142% and 159%, respectively. For details, refer to the Annex 7.

- ***Time series consistency***

Although some basic data used for activity data calculation were not available for entire time series, consistent data over the time series were developed by using estimation. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

Emissions for FY2005 and FY2006 were recalculated owing to update of data used in estimates.

**f) *Source-specific Planned Improvements***

No improvements are planned.

## 8.4.2. Emissions from waste incineration with energy recovery (1.A.)

### 8.4.2.1. Incineration of municipal solid waste with energy recovery (1.A.1.a)

**a) *Source/Sink Category Description***

In this category, $CO_2$, $CH_4$, and $N_2O$ emissions from the incineration of municipal waste during which energy is recovered are calculated 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***

A methodology similar to that used in 8.4.1.1 Incineration of Municipal Waste (6.C.1) is used. Emissions are calculated using the following formulas:

$CO_2$

$$E = EF \times A \times R$$

$E$ : 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 facilities with energy recovery

***1) $CH_4$ , $N_2O$***

$$E = \sum \left( EF_i \times A_i \right) \times R$$

$E$ : 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

**c) *Uncertainties and Time-series Consistency***

Omitted as it is the same as in "Incineration of Municipal Waste (6.C.1).

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

- Emissions from the incineration of municipal waste with energy recovery

Changes were made to report these emissions in Fuel Combustion (Category 1.A.) in accordance with the Revised 1996 IPCC Guidelines. Only emissions from non-energy recovering waste incineration (simple incineration) are reported in Waste Incineration (Category 6.C.). This change affects the reporting categories only, and does not change the total emissions in Japan.

- The emissions for FY2005 and FY2006 were recalculated based on the updated data for the amounts of incinerated waste which had remained unchanged in the past.

**f) *Source-specific Planned Improvements***

No improvements are planned.

### 8.4.2.2. Incineration of industrial solid waste with energy recovery (1.A.1.a)

**a) *Source/Sink Category Description***

In this category, $CO_2$, $CH_4$, and $N_2O$ emissions from the incineration of industrial waste during which energy is recovered are calculated and reported. The reporting category for the emissions is the Power Generation/Heat Supply (Category 1.A.1.a)" and the fuel type is classified as "Other fuels".

**b) *Methodological Issues***

A methodology similar to that used in 8.4.1.2 Incineration of Industrial Waste (6.C.2) is used. Emissions are calculated using the following formulas:

***1) $CO_2$***

$$E = EF \times A \times R$$

$E$ : 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 industrial solid waste incinerated at facilities with energy recovery

***2) $CH_4$ , $N_2O$***

$$E = \sum \left( EF_i \times A_i \right) \times R$$

$E$ : Emissions of $CH_4$ or $N_2O$ from incineration of industrial solid waste (kg $CH_4$) (kg $N_2O$)
$EF_i$ : Emission factor for industrial solid waste incinerator type *j* (wet basis) (kg $CH_4$/t) (kg $N_2O$/t)
$A_i$ : Amount of industrial solid waste incinerated for incinerator type *j* (wet basis) (t)
$R$ : Percentage of industrial solid waste incinerated at facilities with energy recovery

**c) *Uncertainties and Time-series Consistency***

Omitted as it is the same as in 8.4.1.2. Incineration of Industrial Waste (6.C.2).

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

- Changes were made so that emissions from industrial waste incineration where energy is recovered are reported in the Fuel Combustion (Category 1.A.) section in accordance with the Revised 1996

IPCC Guidelines. Only emissions from the non-energy recovering waste incineration (simple incineration) are reported in the Waste Incineration (Category 6.C.) section. This change affects the reporting categories only, and does not change the total emissions in Japan.

-The activity data in both 8.4.2.1. Incineration of Waste and in 8.4.2.2 Incineration of Industrial Waste with Energy Recovery contained the amount of incinerated specially controlled industrial waste used for the calculation of emissions in 8.4.1.3 Incineration of Special Industrial Waste. The duplication was eliminated by deducting the incinerated amount of special industrial waste from the amount of incinerated industrial waste, and the emissions from FY1990 onward were recalculated. For more details, see 8.4.2.1 Incineration of Industrial Waste.

-The emissions for the FY2005 and FY2006 were recalculated based on the updated data for the amounts of incinerated waste which had remained unchanged in the past.

#### 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 calculated and reported. The reporting category for the emissions for each type of waste, according its use as fuel or raw material, is “Energy Industry (Category 1.A.1.)” or “Manufacturing and Construction (1.A.2)”. The fuel type is classified as “Other fuels”.

The GHG 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 calculated 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 8-43 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 rawmaterial | 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 (waste plastics) as alternative fuel or raw material | Blast furnace reducing agent | Blast furnace reducing agent | 1A2a Iron & Steel |
| | Cement burning | Cement burning | 1A2f Cement & Ceramics |
| Use of industrial solid waste (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 |
| | Papermanufacture | Fuel in paper manufacturing | 1A2d Pulp, paper and print |
| | Power generation | Power generation | 1A1a Public electricity and heat production※ |

## b） *Methodological Issues*

### *1） $CO_2$*

- ***Estimation Method***

Carbon dioxide emissions were calculated 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 calculation were the portions used as raw material or fuel of: plastics in municipal solid waste; waste plastics and waste oil in industrial waste and waste tires.; .

- ***Emission factor***

New emission factors were established for the plastics from municipal solid waste that were 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 (simple incineration) (Chapter 8.4.1.).

| | |
|---|---|
| New emission factors | Plastics from municipal solid waste (as chemical raw material in coke ovens) and waste tires |
| Emission factors for simple incineration | Plastics from municipal solid waste (other than those used as chemical material in coke ovens) and industrial waste |

Table 8-44 Carbon dioxide emission factors associated with the incineration of RDF and RPF Plastics from municipal solid waste(as chemical raw material in coke ovens),waste tires (kg $CO_2$/t)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| MSW-coke oven | kg $CO_2$/t(dry) | 1,362 | 1,387 | 1,404 | 1,445 | 1,441 |
| Waste tire | kg $CO_2$/t(dry) | 1,858 | 1,785 | 1,790 | 1,729 | 1,722 |

### ● *Activity Data*

Incinerated amount of waste used as raw material or alternative fuels is used. For more details, refer to the 8.4.3.1. -8.4.3.3.

Table 8-45 Usage as raw materials and fuels (kt)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| MSW-plastics-oilification | kt (dry) | 0.0 | 0.0 | 3.2 | 4.2 | 4.1 |
| MSW-plastics-reducer in blast furnace | kt (dry) | 0.0 | 0.0 | 24.1 | 37.4 | 31.6 |
| MSW-plastics-chemical material in coke-oven | kt (dry) | 0.0 | 0.0 | 10.5 | 149.8 | 137.0 |
| MSW-plastics-gasification | kt (dry) | 0.0 | 0.0 | 0.6 | 52.4 | 54.3 |
| ISW-waste plastics (iron and steel) | kt (wet) | 0.0 | 0.0 | 57.0 | 92.1 | 112.5 |
| ISW-waste plastics (cement) | kt (wet) | 0.0 | 0.0 | 102.0 | 365.0 | 408.0 |
| ISW-waste oil (cement baking furnace) | kt (wet) | 141.0 | 233.0 | 359.0 | 474.0 | 479.0 |
| ISW-waste oil (coiler) | kt (wet) | 569.2 | 656.5 | 482.0 | 831.0 | 826.0 |
| Waste tire | kt (dry) | 282.2 | 471.2 | 580.5 | 546.3 | 576.7 |

## 2） $CH_4$, $N_2O$

### ● *Estimation Method*

Emissions were calculated 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 are not calculated for some of the emission sources. They are summarized below.

Table 8-46 $CH_4$ and $N_2O$ emissions sources not included in calculation for waste used as alternative fuel or raw materials

| Emission source | Emission source (not calculated) |
|---|---|
| Use of municipal solid waste as alternative fuel or raw materials | Blast furnace redusing agent (NO), Coke-oven chemical feedstock (IE), Gasification (NE) |
| Use of industrial solid waste as alternative fuel or raw materials | Balst furnace reducing agent (NO), Petrochemical (NE), Gasification (NE) |
| Use of waste tire as alternative fuel or raw material | Iron manufacturing（NO） |

### ● *Emission factor*

The emission factors for waste used as raw material and fuel were 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 8-47 shows the data used in the calculation.

*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 8-47 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 |
|---|---|---|---|---|
| Plastics from municipal solid waste | | Plastic oil | Boilers (Fuel oil A, gas oil, kerosene, naphtha, other liquid fuels) | Calorific value of waste plastics |
| Industrial waste | Waste plastics | Cement kilns | Other industrial furnaces (solid fuel) | Calorific value of waste plastics |
| | Waste oil | Cement kilns, boilers | Other industrial furnaces (solid fuel) | Specific gravity of reclaimed oil/waste oil [a] |
| | | Boilers | Boilers (Fuel oil A, gas oil, kerosene, naphtha, other liquid fuels) | |
| | Wood scraps | Boilers | $CH_4$: Boilers (wood, charcoal)<br>$N_2O$: 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)<br>$N_2O$: Boilers (other than fluidized-bed) (solid fuel) | |
| | | Carbonization | Boilers (gas fuels) | |
| | | Gasification | Other industrial furnaces (gas fuels) and other industrial furnaces (liquid fuels) [c] | |

a) Calorific value per unit volume was 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 was calculated using the proportions of gas and oil (22% and 43%) reported in the *Hyogo Eco-town* documents.

Table 8-48 Emission factors and calorific values (energy sector) for the use of waste as raw material and fuel by furnace type

| Furnace type/Fuel type | Methane emission factor (kg-$CH_4$/TJ) | Nitrous oxide emission factor (kg-$N_2O$/TJ) | Source of fuel | Calorific value (MJ/kg) |
|---|---|---|---|---|
| Boilers (Fuel oil A, gas oil, kerosene, naphtha, other liquid fuels) | 0.26 | 0.19 | Waste plastics | 29.3 |
| Boilers (gas fuels) | 0.23 | 0.17 | Reclaimed oil* | 40.2 (TJ/l) |
| Boilers (steam coal, coke, other solid fuels) | 0.13 | | Waste tires | 20.9 |
| Boilers (wood, charcoal) | 74.9 | | RDF | 18.0 |
| Boilers (other than fluidized-bed) (solid fuels) | | 0.85 | RPF | 29.3 |
| Other industrial furnaces (liquid fuel) | 0.83 | 1.8 | Wood | 14.4 |
| Other industrial furnaces (solid fuel) | 13.1 | 1.1 | | |
| Other industrial furnaces (gas fuel) | 2.3 | 1.2 | | |

Emission factors are from the documents relating to each furnace type. Calorific values are obtained from “The report of the revised standard calorific values applied since FY 2005” reported by the Agency for Natural Resources and Energy (2007).

* Basic unit of calorific value of oil is “TJ/l”.

### ● *Activity Data*

Activity data were determined for each category using the wet-basis values (Table 8-49).

Table 8-49 Fuel usage of the waste associated with methane and nitrous oxide emissions

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| MSW-oilification | kt (wet) | 0.0 | 0.0 | 3.4 | 4.4 | 4.3 |
| ISW-waste wood | kt (wet) | 1,704.2 | 1,704.2 | 2,061.0 | 3,088.0 | 3,088.0 |
| Waste tire-cement baking furnace | kt (wet) | 111.0 | 275.0 | 361.0 | 168.0 | 148.0 |
| Waste tire-boiler | kt (wet) | 119.0 | 184.0 | 163.0 | 316.0 | 369.0 |
| Waste tire-pyrolysis furnace | kt (wet) | 67.0 | 37.0 | 30.0 | 8.0 | 8.0 |
| Waste tire-gasification | kt (wet) | 0.0 | 0.0 | 0.0 | 34.0 | 42.0 |

**c) *Uncertainties and Time-series Consistency***

Refer to the respective section.

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

Refer to the respective section.

**e) *Source-specific Recalculations***

Refer to the respective section.

**f) *Source-specific Planned Improvements***

Refer to the respective section.

#### 8.4.3.1. Emissions from municipal waste (waste plastics) used as alternative fuel (1.A.1 and 1.A.2)

**a) *Source/Sink Category Description***

This category includes the emissions from municipal waste used as raw materials or alternative fuels.

**b) *Methodological Issues***

***1) $CO_2$***

● ***Estimation Method***

The emissions were calculated by multiplying the incinerated volume of each type of waste used as raw material or fuel by Japan's country-specific emission factor.

● ***Emission factor***

Emission factors of municipal waste incineration were used except for plastics of municipal solid waste (as chemical raw material in coke ovens). 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 carbon dioxide 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)<br>= (Emission factor for the incineration of plastics in municipal solid waste)<br>× [1 – (fraction of carbon in plastics used as chemical raw material for coke ovens that migrates to hydrocarbon)] |

● ***Activity Data***

The portion of the plastics in municipal solid waste used as raw material or fuel (dry basis) was determined by multiplying the total amount collected by designated legal bodies and municipalities and processed as raw material and fuel (wet basis) under the Containers and Packaging Recycling Law by the percentage of solids. The percentage of solids was established 96% by using the data provided by the Japan Containers and Packaging Recycling Association.

- ***Processing of plastics collected by designated legal bodies***

The amount of the plastics collected by designated legal bodies and processed into raw material and fuel was determined from the amount reported 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 carbon dioxide was deducted.

- ***Processing of plastics collected by municipalities***

The amount of plastics collected by municipalities and processed into raw material and fuel was calculated by first subtracting the amount of plastics (wet basis) that was commercially recycled through designated legal bodies from the amount of all plastics that were commercially recycled under the *Plastic Containers and Packaging Recycling Law* (wet basis), and multiplying the result by the recycling rate of plastics by various methods and the percentage of recycled products in the total amount of the product.

- 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* were determined from *Annual Recycling Statistics* by the Waste Management and Recycling Department of the Ministry of the Environment.

- 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).*

- Percentage of commercially recycled plastics by recycling method

  The rates were 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.

- Percentage of commercially recycled plastic products by recycling method

  The values for the commercial recycling of the plastics collected through the municipal channels were substituted for the percentage of commercially recycled plastic products collected through designated legal body channels. The percentages were calculated by dividing the amounts of commercially recycled plastic products by various recycling methods, which were 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 reference documents *Assessment and Deliberation of the Plastic Containers and Packaging Recycling Law* by the Japan Containers and Packaging Recycling Association.

#### 2） $CH_4$, $N_2O$

For estimation method and emission factors, refer to the section “8.4.3. Emissions from direct use of waste as fuel”. Data used for $CO_2$ emission estimates were used in wet basis for activity data.

### c） *Uncertainties and Time-series Consistency*

● ***Uncertainties***

The same value of uncertainty in $CO_2$ emissions from incineration of municipal solid waste (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 solids (same value that was used for the municipal solid waste incineration).

The level of uncertainty in the $CH_4$ emission factor was estimated by using the uncertainties in emission factors for each furnace type (energy sector) and the calorific value of plastics. For uncertainty in $CH_4$ and $N_2O$ activity data, the uncertainties in the amount of municipal solid waste plastics used as raw materials or alternative fuels were used. The uncertainties in the $CO_2$, $CH_4$ and $N_2O$ emissions from municipal solid waste plastics used as raw materials or alternative fuels were estimated to be 17%, 180% and 112%, respectively. For details, refer to the Annex 7.

● ***Time series consistency***

The emissions were calculated in a consistent manner. The statistical data for activity data have been available since 2000 because the use of waste as alternative fuel or raw material was not common prior to 2000 in Japan.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e）*Source-specific Recalculations***

-A minor correction to the activity data for 2006 was made.
-The category for reporting emissions was changed from Waste Incineration (6.C.) to Fuel Combustion (1.A.).

**f）*Source-specific Planned Improvements***

No improvements are planned.

### 8.4.3.2. Emissions from industrial waste (waste plastics, waste oil, waste wood) used as raw material or alternative fuels (1.A.2.))

**a）*Source/Sink Category Description***

This category includes GHG emissions from industrial waste (waste plastics, waste oil, waste wood) used as raw material or alternative fuels.

**b）*Methodological Issues***

***1）$CO_2$***

● ***Estimation Method and Emission factor***

Emission factors used for incineration of industrial waste are used for waste plastics and waste oil.

● ***Activity Data***

**- Industrial waste plastics used as raw materials and fuels**

The calculation covered the amount (wet basis) of waste plastics in industrial waste that was used as raw material or fuel in the Steel Industry and the Cement Manufacturing Industry categories. Usage of raw material or fuel in the steel industry was obtained from the *Current State of Plastic Waste Recycling and Future Tasks* published by the Japan Iron and Steel Federation. Usage in the cement manufacturing industry was obtained from the *Cement Handbook* published by Japan Cement Association

**- Industrial waste oil used as raw materials and fuels**

The amount of waste oil used as raw material or fuel was extracted from the “fuel usage” in the "direct recycle usage category" and the "fuel usage" in the "recycle usage after treatment category" in the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*. The values before 1998 are estimated by using the trend of incineration amount of all industrial waste oil.

**2) $CH_4$, $N_2O$**

- ***Estimation Method and Emission factor***

Refer to the section "8.4.3. Emissions from direct use of waste as fuel"

- ***Activity Data***

**- Waste plastics used as raw materials and fuels**

The calculation of the usage of wastes plastics as raw material or fuel associated with the source of methane and nitrous oxide emissions covered cement kilns. The activity data determined during the calculation of carbon dioxide emissions relevant to cement kilns was used.

**- Waste oil used as raw materials and fuels**

The volume of waste oil used as raw material or fuel is calculated separately for cement kilns and boilers. The volume 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 volume used as fuel for boilers was determined by subtracting the volume used as fuel for cement kilns from the volume of waste oil used as raw material or fuel, which was determined during the calculation of the carbon dioxide emission from this source.

**- Waste wood used as raw materials and fuels**

The amount of usage of waste wood as raw material or fuel was extracted 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 and Cyclical Use of Wastes. The values before 1998 are estimated by using the average value in the period of 1998-2002.

**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 for uncertainty in $CO_2$ emission factor. The uncertainties in emission factors for $CH_4$ and $N_2O$ were evaluated by the same method that was used for municipal waste used as raw materials or alternative fuels. The uncertainty in activity data were evaluated separately for waste plastics, waste oil, and waste wood. For waste plastics, the uncertainty was calculated by combining of the uncertainties in the amount of waste 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 were evaluated by using the statistical uncertainties. For waste oil, the values for cement kilns (statistical uncertainty) and boilers (a value for $CO_2$) were combined. For waste wood, statistical uncertainties for the amount of waste wood used as raw materials or alternative fuels were 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 were estimated to be in the range of 13-105%, 74-128% and 31-110%, respectively. For details, refer to the Annex 7.

- ***Time series consistency***

Data on the amount of waste oil and waste wood used as alternative fuels have been available since 1998. For waste oil, consistent data over the time series were developed by using the total amount of waste oil incinerated without the use of waste oil as alternative fuel. For waste wood, the average of 1998–2002 data was used to estimate the amount of waste wood for the past years. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

- The emissions were recalculated according to the updated source data for the activity data for FY2004 to FY2006, and newly captured amounts for the direct cyclic use of wood waste for the period from FY2001 to FY2005.
-The category for reporting emissions was changed from Waste Incineration (6.C.) to Fuel Combustion (1.A.).

**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 were 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 rate 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 rate of combustion for waste tires was set to 99.5% based on the maximum default value for hazardous waste in the Good Practice Guidance (2000).

*Calculation of emission factor for the incineration of waste tires (dry basis)*
= (Fossil fuel-derived carbon content in waste tires) × (rate of combustion of waste tires) × 1000× 44 / 12

- ***Activity Data***

Activity data (dry basis) was calculated by multiplying 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. by the percentage of solids calculated using the average moisture content in the waste tires determined from analyses of three constituents of divided tires reported in *the Basic Waste Data Fact Book 2000*) published by Japan Environmental Sanitation Center.

### 2) $CH_4$, $N_2O$

- ***Estimation Method and Emission factor***

Refer to the section 8.4.2.

Table 8-50 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)<br>$N_2O$: 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)<br>$N_2O$: Boilers (other than fluidized-bed) (solid fuel) | |

※ : 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***

The "volume of waste tires used as raw material or fuel by usage" that was determined during the calculation of the carbon dioxide emissions from this source was used. For the activity data, the volume of waste tires recorded in the following categories were 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; 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 solids in waste tires. The uncertainties in the emission factors for $CH_4$ and $N_2O$ were evaluated by the same method that was applied to municipal solid waste used as raw materials or alternative fuels and were estimated by combining the uncertainties in emission factors for each furnace type ($CH_4$, $N_2O$ of 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 were used. The methods of evaluation of the uncertainty levels for each component are:

- Use of the values for industrial waste (waste plastics) incineration: carbon content and combustion rate
- Based on expert judgment: percentage of solids
- 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 were estimated to be 15%, 91% and 26%, respectively. For details, refer to the Annex 7.

- ***Time series consistency***

The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the

verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

The category for reporting emissions was changed from Waste Incineration (6.C.) to Fuel Combustion (1.A.).

**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.2)

**a) *Source/Sink Category Description***

In this category, $CO_2$, $CH_4$, and $N_2O$ emissions from waste which is processed and used as fuel are calculated and reported. Refuse-derived solid fuels (RDF, RPF) are used for the calculation of emissions from fuels produced from waste. The reporting categories for the above emissions are included in Manufacturing/Construction (1.A.2) according to the use of waste as fuels. The fuel type is classified as Other fuels.

Table 8-51 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 (paper manufacture) | Fuel use in paper manufacturing | 1A2d Pulp, paper and print |
| | RPF (cement burning) | Cement burning | 1A2f Cement & ceramics |

※ : *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***

The emissions were calculated by multiplying the incinerated amount of RDF and RPF by Japan's country-specific emission factor.

- ***Emission factor***

The emission factor associated with the use of the refuse-derived solid fuels was calculated separately for RDF and RPF by the equation shown below. For the RPF (refuse paper and plastic fuel), the emission factors were calculated separately for the coal-equivalent and coke-equivalent fuels, and also calculated their average weighted by the percentage used as fuel.

| |
|---|
| *Calculation of emission factor for the use of RDF and RPF as fuel (dry basis)* |
| = 1000 × (average percentage of solids) × (percentage of plastic-derived constituents, dry basis) × (carbon content of plastics, dry basis) × (rate of combustion) × 44 / 12 |

**- Average percentage of solid content**

The percentage of solids in the RDF was set to 94.5%, based on the simple average of moisture content in the RDF manufactured by the facilities listed in the Proper Management of Refuse-derived Fuels compiled by the Study Group for Proper Management of RDF.

The percentage of solids in the RPF was set to 97.4%, based on the moisture contents of coal-equivalent and coke-equivalent products indicated by the RPF quality standards set by the Japan RPF Industry Association with their average weighted by the manufacturing ratio of these products.

**- Percentage of plastic-derived content**

The calculation of the percentage of the plastics-derived constituents (dry basis) used the wet-based moisture content of the constituents of municipal solid waste determined in the Emission from Controlled Disposal Sites (6.A.1.) section, which was converted to a dry-based value. The results of the content analysis of the wet-based refuse were obtained from the Results of Content Analysis of Refuse for each facility listed in the Proper Management of Refuse-derived Fuels. The percentage of plastics-derived constituents in the RPF (dry basis) was set at 50% for the coal-equivalent product and 90% for the coke-equivalent product based on the results of a fact-finding survey by the Japan RPF Industry Association.

**- Carbon content in plastics**

The average carbon content used in the Incineration of Municipal Solid Waste (Plastics) (Table 8-29) was applied to the carbon content in plastics contained in the RDF (dry basis). The carbon content (73.7%) of plastics contained in the RPF (dry basis) was determined from the carbon content value (70%) used in the Incineration of Industrial Waste (Waste Plastics) (95%), which was converted to a dry basis using the moisture content in waste plastics in industrial waste.

**- Rate of combustion**

The rate of combustion of the RDF was set to 99%, applying the default value in the Good Practice Guidance (2000) in the same manner as for municipal solid waste (plastics). The rate for the RPF was set to 99.5%, using the default value in the Good Practice Guidance (2000) in the same manner as for industrial waste (waste plastics).

Table 8-52 $CO_2$ emission factors for the emissions from the use of refuse derived fuel as fuel

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| RDF | kg $CO_2$/t(dry) | 1,029 | 1,029 | 1,029 | 1,029 | 1,029 |
| RPF (Coal) | kg $CO_2$/t(dry) | 1,419 | 1,419 | 1,419 | 1,419 | 1,419 |
| RPF (Coke) | kg $CO_2$/t(dry) | 2,445 | 2,445 | 2,445 | 2,445 | 2,445 |
| RPF (weighted average) | kg $CO_2$/t(dry) | 1,627 | 1,627 | 1,627 | 1,627 | 1,627 |

● ***Activity Data***

The amount of RDF production was used as the substitute for the amount of usage of the RDF fuel. The activity data was calculated by multiplying the percentage of solids in the RDF by the amount of fuel produced by refuse-based fuel production facilities (wet basis) indicated in the Report on Survey of State of Treatment of Municipal Solid Waste compiled by the Waste Management and Recycling Department of the Ministry of the Environment. The values for the years for which data were unavailable were estimated using the refuse processing capacity.

Determining the usage of RPF covered the paper and cement manufacturing industries which consumed a significant amount of the RPF. The usage of the RPF was calculated by multiplying the average percentage of solids in the RPF by the value in the statistical data compiled by the Japan Paper Association (dry basis) for the paper industry and by the statistical data compiled by the Japan

Cement Association (wet basis) for the cement industry.

Table 8-53 Use of refuse derived fuel (RDF, RPF) as fuel

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| RDF | kt (dry) | 31.7 | 36.7 | 140.0 | 373.5 | 373.5 |
| RPF | kt (dry) | 0.0 | 7.9 | 24.5 | 619.8 | 727.4 |

### 2) $CH_4$, $N_2O$

- ***Estimation Method and Emission factor***

For the estimation method and the emission factors used, refer to 8.4.3 Emissions from Waste Directly Used as Fuels. Although up to the 2008 submission of the inventory report the standard calorific value for RPF was calculated using the property data prepared by an industry association, from the 2009 submission the data source has been switched to the Report on the Results of Discussions and Revised Values for Standard Calorific Values to be Used in FY2005 and Subsequent Years (Resources and Energy Agency).

- ***Activity Data***

The total production volume of RDF (wet basis) determined during the calculation of the carbon dioxide emissions from this source was used as the volume of RDF burnt as boiler fuel.

Of the total production volume of the RPF determined during the calculation of carbon dioxide emission from this source, the volume used by the paper industry was used as the volume for the boiler fuel usage, and the volume used by the cement industry was used as the volume for the fuel usage by cement kilns. The fuel usage of the RPF in the paper industry was reported on a dry basis; this was converted to the wet-basis weight by dividing the value by the percentage of solids in the RPF determined during the calculation of the carbon dioxide emission.

### 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 using the uncertainties in the amount (wet basis) of RDF, RPF used as fuels and the percentage of solids in the solid fuels.

The uncertainties in the $CH_4$ and $N_2O$ emission factors were estimated by using the uncertainties in emission factors for each type of furnace 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 were 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 solids in RDF
- Use of the values for municipal solid waste (plastics) incineration: carbon content of RDF and combustion rate for RDF
- Use of the values for industrial solid waste (waste 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 were estimated to be 44%, 49%, and 33%, respectively. For details, refer to the Annex 7.

- ***Time-series consistency***

Because data on the amount of RDF produced were not available for the years prior to 1997, these data were estimated by using the trend on capacity of refuse-based fuel-producing facilities. The emissions were calculated in a consistent manner.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e)** ***Source-specific Recalculations***

-Emissions estimates were recalculated owing to update of RPF and RDF incineration amounts for FY2006 and revision of RPF calorific value.

-The category for reporting emissions was changed from Waste Incineration (6.C.) to Fuel Combustion (1.A.).

**f)** ***Source-specific Planned Improvements***

No improvements are planned.

## 8.5. Other (6.D.)

In this category, $CO_2$ emitted 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. Emissions from composting were previously reported in 6A, but this was changed to 6D. In 2007, the emission from this source category was 591 Gg $CO_2$ eq. and accounted for 0.04% of the national total emissions. The emissions from this source category had decreased by 19.0% compared to 1990.

### 8.5.1. Emissions from Composting of Organic Waste (6.D.1)

**a)** ***Source/Sink Category Description***

Part of the municipal solid waste and industrial waste generated in Japan is composted, and the methane and nitrous oxide generated in that process are emitted from composting facilities. Emissions from composting of livestock waste are accounted for under “Emissions from manure treatment” (4.B) in the Agriculture sector.

**b)** ***Methodological Issues***

- ***Estimation Method***

Emissions were calculated by taking the amount of organic waste composted, which was extracted 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 $CH_4$ ($N_2O$) emissions generated by composting organic waste (kg $CH_4$ or 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)

- ***Emission factor***

In accordance with the 2006 IPCC Guidelines, emission factors (dry basis) are set as 10.0 (kg $CH_4$/t) for methane and 0.6 (kg $N_2O$/t) for nitrous oxide, respectively, for all fiscal years.

- ***Activity data***

The activity data (amount composted on a dry basis) is calculated by multiplying the amount of waste to be composted (emission basis) by a percentage of solids calculated according to the properties of the waste to be composted.

The amount of composted municipal solid waste is determined for each type by multiplying the amount of municipal solid waste for high-rate composting facilities in "State of Waste Treatment" in *Waste Treatment in Japan* by the percentages of constituents of municipal solid waste in high-rate composting facilities in "Percentages of Constituents in Waste to Be Treated According to Facility" in the *Report of the Research on the State of Wide-range Movement and Cyclical Use of Wastes*. As the amount of composted industrial waste, we used the input amount of sludge into composting facilities given in "Farmland Use (Composting Facilities)" for sewage sludge in *Sewage Statistics*. Percentage of the solids contained in composted waste, established in the Emissions from Controlled Disposal Sites (6.A.1) section, are: 80% in waste paper, 25% in kitchen waste, 80% in textile waste, 55% in wood waste, and 30% in sewage sludge.

Table 8-54 Amounts of composted waste (kt)

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Municipal solid waste | kt (dry) | 38 | 22 | 29 | 29 | 29 |
| Industrial solid waste | kt (dry) | 31 | 33 | 34 | 50 | 50 |

### c) *Uncertainties and Time-series Consistency*

- ***Uncertainties***

The level of 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 were estimated to be 74% and 86.3%, respectively. For more details, refer to the Annex 7.

- ***Time series consistency***

With respect to the input of municipal waste at composting facilities, due to changes in the statistical classification, the data used for FY2005 and subsequent years covered a wider scope than those used in the FY2004 and years prior. Consequently, the continuity of values between FY2004 and FY2005 is not maintained. Re-tabulation of the 1990–2004 data according to the current classification is now in progress, and the activity data will be updated as soon as the new data become available. The methodology itself, however, remains consistent.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the

verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e) *Source-specific Recalculations***

-Emissions estimates since FY1990 were recalculated owing to calculation of emissions based on dry-based activity data and emission factors.

-The reporting of $CH_4$ emissions from composting was changed from the Surface Disposal of Solid Waste (6.A.) category to the Other (6.D.) category. This change affects the reporting categories only, and does not change the total emissions in Japan.

**f) *Source-specific Planned Improvements***

As stated above, a review of activity data based on the actual state of activity data relating to the composting of municipal waste is scheduled.

### 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 in homes and factories in Japan. Petroleum-derived surfactants discharged into wastewater treatment facilities and into the environment, and emit carbon dioxide. 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 Good Practice Guidance (2000) specified a method for determining carbon dioxide 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 carbon dioxide and emitted into the atmosphere as a result of surfactants decomposition, carbon dioxide emissions were estimated based on the amount of carbon contained in surfactants that emitted into wastewater treatment facilities and into the environment.

The main subject of estimation was the carbon content of petroleum-derived surfactants, and it was assumed that all of the carbon contained in surfactants is ultimately decomposed into $CO_2$. In addition, all domestically used surfactants were assumed to be discharged into wastewater treatment facilities and into the environment. The carbon content in petroleum-derived surfactants was determined by using the amount of surfactant raw materials consumed and the amount of surfactants imported and exported.

Based on the facts stated above, the carbon dioxide emissions were 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***

The emission factor was determined for each type of material by calculating the amount of carbon dioxide, expressed in kg, that was emitted from the decomposition of 1 t of a surfactant, using the average carbon content in the molecules.

$$EF_j = C_i \times 1000 / 12 \times 44$$

$C_i$: Average carbon content of petroleum-derived raw material *i* used in a surfactant

Table 8-55 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 were 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 were extracted from the consumption of raw materials for surfactants indicated in the Chemical Industry Statistical Yearbook. As there was no compilation of usage since 2002, the volume of use was estimated using the simple averages of ratio of consumption and production in the period from 1990 to 2001.

➢ ***Export/import correction factor***

The 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 were 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 8-56 Activity data associated with decomposition of petroleum-based surfactants

| Item | Unit | 1990 | 1995 | 2000 | 2006 | 2007 |
|---|---|---|---|---|---|---|
| Synthetic alcohol | t | 29,239 | 16,253 | 28,285 | 34,575 | 36,714 |
| Alkyl benzene | t | 105,432 | 102,794 | 80,832 | 46,281 | 51,249 |
| Alkyl phenol | t | 10,141 | 8,798 | 7,454 | 3,184 | 3,084 |
| Ethylene oxide | t | 124,984 | 132,175 | 146,509 | 132,828 | 140,644 |

**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 the statistical uncertainties 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 became not available since 2002 and activity data were estimated from the production amount of the surfactants.

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

Tier 1 QC activities described in GPG (2000) were implemented. The QC activities focus on the verification of the parameters for activity data and emission factors and the archive of reference materials. For more details, refer to the Annex 6.

**e)** ***Source-specific Recalculations***

Due to minor changes made to the values in trade statistics, the results of the emission calculation have been slightly modified for certain years.

**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) para.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 included in the IPCC Guidelines. According to this requirement, emissions from other category (CRF sector7) are indicated below.

## 9.2. $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs and $SF_6$

The national inventory submitted this year does not include the emissions and removals of gases targeted under the Kyoto Protocol ($CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$) from the sources which are not included in the IPCC Guideline.

## 9.3. NOx, CO, NMVOC and $SO_2$

The inventory submitted this year includes CO emissions from smoking as the emissions of indirect greenhouse gases (NOx, CO, NMVOC) and $SO_2$ from the sources which are not included in the IPCC Guideline.

# 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 2009.

In accordance with the *Good Practice and Uncertainty Management in National Greenhouse Gas Inventories (2000)* (hereafter, *the Good Practice Guidance (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 in the inventory submitted last year 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 2006 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.

## 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”.

Compared to the values reported in the previous year’s inventory, total emissions excluding LULUCF sector in the base year (1990) under the UNFCCC decreased by 0.20%, and the total emissions in year 2006 increased by 0.15% compared to the data reported in last year (Table 10-1).

Table 10-1 Comparison of emissions and removals in the inventories submitted in 2007 and 2008

[Mt $CO_2$eq.]

| | | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $CO_2$ | JNGI2008 | 1,052.2 | 1,062.7 | 1,071.9 | 1,064.3 | 1,124.5 | 1,134.6 | 1,147.8 | 1,143.6 | 1,107.7 | 1,143.2 | 1,164.1 | 1,148.3 | 1,176.0 | 1,183.7 | 1,182.2 | 1,194.7 | 1,182.1 |
| with LULUCF[3)] | JNGI2009 | 1,068.8 | 1,078.4 | 1,087.0 | 1,078.6 | 1,137.8 | 1,147.0 | 1,159.0 | 1,154.7 | 1,118.8 | 1,153.6 | 1,174.0 | 1,158.0 | 1,185.6 | 1,192.5 | 1,190.9 | 1,201.7 | 1,188.4 |
| | *difference* | *1.59%* | *1.48%* | *1.41%* | *1.35%* | *1.18%* | *1.09%* | *0.98%* | *0.98%* | *1.00%* | *0.91%* | *0.85%* | *0.85%* | *0.81%* | *0.75%* | *0.74%* | *0.59%* | *0.54%* |
| $CO_2$ | JNGI2008 | 1,144.2 | 1,153.6 | 1,161.8 | 1,154.6 | 1,214.5 | 1,228.1 | 1,241.1 | 1,236.8 | 1,200.5 | 1,235.8 | 1,256.7 | 1,240.7 | 1,278.6 | 1,286.2 | 1,284.4 | 1,290.6 | 1,273.6 |
| without LULUCF | JNGI2009 | 1,143.2 | 1,152.6 | 1,160.8 | 1,153.6 | 1,213.5 | 1,226.6 | 1,238.9 | 1,234.9 | 1,198.9 | 1,233.9 | 1,254.6 | 1,238.8 | 1,276.7 | 1,283.9 | 1,282.5 | 1,287.3 | 1,270.2 |
| | *difference* | *-0.09%* | *-0.09%* | *-0.09%* | *-0.09%* | *-0.08%* | *-0.12%* | *-0.18%* | *-0.15%* | *-0.13%* | *-0.16%* | *-0.17%* | *-0.15%* | *-0.15%* | *-0.18%* | *-0.15%* | *-0.25%* | *-0.27%* |
| $CH_4$ | JNGI2008 | 33.5 | 33.2 | 33.0 | 32.7 | 32.0 | 31.0 | 30.3 | 29.2 | 28.4 | 27.7 | 27.0 | 26.2 | 25.3 | 24.8 | 24.4 | 24.0 | 23.7 |
| with LULUCF | JNGI2009 | 32.6 | 32.4 | 32.1 | 31.9 | 31.2 | 30.2 | 29.6 | 28.5 | 27.7 | 27.0 | 26.4 | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 |
| | *difference* | *-2.55%* | *-2.59%* | *-2.68%* | *-2.62%* | *-2.60%* | *-2.60%* | *-2.56%* | *-2.55%* | *-2.54%* | *-2.49%* | *-2.42%* | *-2.40%* | *-2.35%* | *-2.32%* | *-2.33%* | *-2.23%* | *-2.64%* |
| $CH_4$ | JNGI2008 | 33.4 | 33.1 | 32.9 | 32.6 | 31.9 | 31.0 | 30.3 | 29.2 | 28.4 | 27.7 | 27.0 | 26.2 | 25.3 | 24.8 | 24.4 | 24.0 | 23.7 |
| without LULUCF | JNGI2009 | 32.6 | 32.4 | 32.1 | 31.8 | 31.1 | 30.2 | 29.5 | 28.5 | 27.6 | 27.0 | 26.4 | 25.6 | 24.7 | 24.2 | 23.8 | 23.4 | 23.0 |
| | *difference* | *-2.29%* | *-2.32%* | *-2.38%* | *-2.40%* | *-2.41%* | *-2.40%* | *-2.66%* | *-2.67%* | *-2.58%* | *-2.51%* | *-2.45%* | *-2.44%* | *-2.43%* | *-2.33%* | *-2.38%* | *-2.27%* | *-2.65%* |
| $N_2O$ | JNGI2008 | 32.7 | 32.2 | 32.3 | 32.0 | 33.2 | 33.5 | 34.6 | 35.2 | 33.8 | 27.4 | 29.9 | 26.5 | 26.1 | 25.9 | 26.0 | 25.6 | 25.6 |
| with LULUCF | JNGI2009 | 32.1 | 31.5 | 31.6 | 31.3 | 32.5 | 32.9 | 33.9 | 34.6 | 33.1 | 26.8 | 29.3 | 25.8 | 25.5 | 25.2 | 25.3 | 24.9 | 24.7 |
| | *difference* | *-2.06%* | *-2.13%* | *-2.25%* | *-2.18%* | *-2.03%* | *-1.85%* | *-1.84%* | *-1.79%* | *-1.85%* | *-2.29%* | *-2.10%* | *-2.42%* | *-2.55%* | *-2.65%* | *-2.60%* | *-2.85%* | *-3.23%* |
| $N_2O$ | JNGI2008 | 32.6 | 32.1 | 32.2 | 32.0 | 33.1 | 33.4 | 34.6 | 35.2 | 33.8 | 27.4 | 29.9 | 26.5 | 26.1 | 25.9 | 26.0 | 25.6 | 25.6 |
| without LULUCF | JNGI2009 | 32.0 | 31.5 | 31.5 | 31.3 | 32.5 | 32.8 | 33.9 | 34.6 | 33.1 | 26.7 | 29.3 | 25.8 | 25.5 | 25.2 | 25.3 | 24.8 | 24.7 |
| | *difference* | *-1.96%* | *-2.03%* | *-2.16%* | *-2.10%* | *-1.97%* | *-1.79%* | *-1.95%* | *-1.87%* | *-1.93%* | *-2.38%* | *-2.17%* | *-2.49%* | *-2.62%* | *-2.71%* | *-2.65%* | *-2.89%* | *-3.27%* |
| HFCs | JNGI2008 | NE | NE | NE | NE | NE | 20.2 | 19.8 | 19.8 | 19.3 | 19.8 | 18.6 | 15.8 | 13.1 | 12.5 | 8.3 | 7.3 | 6.6 |
| | JNGI2009 | 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 | 10.6 | 11.6 |
| | *difference* | *NA* | *NA* | *NA* | *NA* | *NA* | *0.24%* | *0.31%* | *0.49%* | *0.63%* | *0.75%* | *1.15%* | *2.09%* | *4.14%* | *9.92%* | *26.36%* | *46.02%* | *75.63%* |
| PFCs | JNGI2008 | NE | NE | NE | NE | NE | 14.3 | 14.9 | 16.1 | 13.2 | 10.5 | 9.3 | 7.8 | 7.1 | 6.8 | 7.0 | 6.5 | 6.3 |
| | JNGI2009 | NE | NE | NE | NE | NE | 14.4 | 14.9 | 16.3 | 13.5 | 10.6 | 9.7 | 8.1 | 7.5 | 7.3 | 7.5 | 7.1 | 7.4 |
| | *difference* | *NA* | *NA* | *NA* | *NA* | *NA* | *0.43%* | *-0.07%* | *1.02%* | *2.19%* | *1.21%* | *4.25%* | *3.46%* | *6.26%* | *6.44%* | *7.12%* | *8.77%* | *16.79%* |
| $SF_6$ | JNGI2008 | NE | NE | NE | NE | NE | 16.9 | 17.5 | 14.8 | 13.4 | 9.1 | 6.9 | 5.7 | 5.4 | 4.8 | 4.6 | 4.2 | 4.3 |
| | JNGI2009 | NE | NE | NE | NE | NE | 17.0 | 17.5 | 15.0 | 13.6 | 9.3 | 7.3 | 6.0 | 5.7 | 5.4 | 5.3 | 4.6 | 5.1 |
| | *difference* | *NA* | *NA* | *NA* | *NA* | *NA* | *0.19%* | *0.23%* | *1.46%* | *1.59%* | *2.19%* | *5.77%* | *5.63%* | *6.33%* | *12.17%* | *15.99%* | *8.37%* | *18.36%* |
| Total | JNGI2008 | 1,118.4 | 1,128.2 | 1,137.2 | 1,129.0 | 1,189.6 | 1,250.6 | 1,265.0 | 1,258.8 | 1,215.8 | 1,237.7 | 1,255.7 | 1,230.3 | 1,253.0 | 1,258.5 | 1,252.5 | 1,262.2 | 1,248.6 |
| with LULUCF | JNGI2009 | 1,133.5 | 1,142.3 | 1,150.7 | 1,141.8 | 1,201.4 | 1,261.7 | 1,274.9 | 1,269.0 | 1,226.2 | 1,247.2 | 1,265.4 | 1,239.7 | 1,262.7 | 1,268.4 | 1,263.4 | 1,272.3 | 1,260.4 |
| | *difference* | *1.36%* | *1.25%* | *1.19%* | *1.13%* | *0.99%* | *0.89%* | *0.78%* | *0.82%* | *0.85%* | *0.77%* | *0.77%* | *0.76%* | *0.77%* | *0.79%* | *0.87%* | *0.80%* | *0.95%* |
| Total | JNGI2008 | 1,210.2 | 1,218.9 | 1,227.0 | 1,219.1 | 1,279.5 | 1,343.9 | 1,358.3 | 1,352.0 | 1,308.6 | 1,330.3 | 1,348.4 | 1,322.8 | 1,355.6 | 1,361.0 | 1,354.8 | 1,358.1 | 1,340.1 |
| without LULUCF | JNGI2009 | 1,207.8 | 1,216.5 | 1,224.5 | 1,216.7 | 1,277.1 | 1,341.2 | 1,354.7 | 1,349.1 | 1,306.2 | 1,327.5 | 1,346.0 | 1,320.5 | 1,353.7 | 1,359.7 | 1,355.0 | 1,357.8 | 1,342.1 |
| | *difference* | *-0.20%* | *-0.20%* | *-0.20%* | *-0.20%* | *-0.19%* | *-0.20%* | *-0.27%* | *-0.21%* | *-0.18%* | *-0.21%* | *-0.18%* | *-0.17%* | *-0.14%* | *-0.10%* | *0.02%* | *-0.02%* | *0.15%* |

## 10.3. Implication for Emission Trends, including Time Series Consistency

Table 10-2 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 2007 submission (JNGI2007) and the 2008 submission (JNGI2008) applies the comparison values between the base year and FY2006.

The actual emissions of HFCs, PFCs, and $SF_6$ prior to CY1995 are not reported; hence, the comparison between JNGI2008 and JNGI 2009 of these emissions applies the comparison values between CY1995 and CY2005.

Total emissions excluding LULUCF sector in the 2009 submission increased by approximately 4.2 million tons (in $CO_2$ equivalents) and increased by 0.4 points, compared to the data reported in the previous submission.

Table 10-2 Comparison of increase and decrease from the base year, between the inventories submitted in 2008 and 2009 excluding LULUCF sector

| | | Trend [Mt $CO_2$eq.] | | | Trend (%) | | |
|---|---|---|---|---|---|---|---|
| | | JNGI2008 | JNGI2009 | Difference | JNGI2008 | JNGI2009 | Difference |
| $CO_2$ | 1) | 129.4 | 127.0 | -2.4 | 11.3% | 11.1% | -0.2% |
| $CH_4$ | 1) | -9.7 | -9.6 | 0.1 | -29.1% | -29.4% | -0.3% |
| $N_2O$ | 1) | -7.1 | -7.3 | -0.2 | -21.6% | -22.7% | -1.0% |
| HFCs | 2) | -13.6 | -8.6 | 5.0 | -67.3% | -42.6% | 24.6% |
| PFCs | 2) | -8.0 | -7.0 | 1.0 | -55.8% | -48.6% | 7.2% |
| $SF_6$ | 2) | -12.6 | -11.8 | 0.8 | -74.3% | -69.7% | 4.7% |
| Total | 3) | 78.5 | 82.7 | 4.2 | 6.2% | 6.6% | 0.4% |

1) Comparison of emissions between FY1990 and FY2006
2) Comparison of emissions between CY1995 and CY2006
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 2006

## 10.4. Recalculations, including in response to the review process, and planned improvements to the inventory

### 10.4.1. Improvements from inventory submitted in 2008

The major improvements carried out since submission of the 2008 inventory are listed below.

#### 10.4.1.1. Methodology for estimating emissions and removals of GHGs

Changed calculation methods are as follows. See each category for details.

1. The emission factors for “1.B.2.b.iv Fugitive Emissions from Natural Gas Distribution” were changed on the basis of new data.
2. Under the reasoning that emissions of “1.B.2.b.v Fugitive Emissions at Industrial Plants and Power Stations and in Residential and Commercial Sectors” are included in “1.B.2.b.iv Fugitive Emissions from Natural Gas Distribution”, $CH_4$ emissions were reported as “IE”. Because $CO_2$ is not included in these emissions, $CO_2$ emissions were reported as “NA”.
3. Japan-specific emission factor indicative of the actual situation was adopted for “2.A.2. Lime Production”.
4. According to the mandatory of greenhouse gas accounting and reporting system, the data in the industrial processes sector for halocarbons and SF6 were reviewed for all time series.
5. PFC emissions were reported as “NO” for “2.F.1. Refrigeration and Air Conditioning Equipment” because the state of PFC emissions was determined. Also, the estimation methods for the emissions from commercial refrigeration and stationary air-conditioning (household) were revised.
6. Emissions for “2.F.9 Other” were reported as “IE” because the state of emissions was determined.
7. $N_2O$ emissions for “3.D. Other/Fire Extinguishers” were reported as “NO” because the actual situation of emissions was determined.
8. For the activity data of sheep, goats, and horses under “4.A. Enteric Fermentation” and “4.B. Manure Management”, statistical data were changed from “FAO statistics” to data provided by the Ministry of Agriculture, Forestry and Fisheries, which more accurately show the actual situation. In conjunction with that change, the activity data of “4.D.3. Indirect Emissions (atmospheric deposition, nitrogen leaching and runoff): $N_2O$” were changed.
9. The parameters of “amount of manure per head” under “4.B. Manure Management” were changed to those in “Intensities for Estimating Livestock Manure Amounts, Harada et al. (1997),” which reflect the actual situation. In conjunction with that change, the activity data of “4.D.3. Indirect Emissions (atmospheric deposition, nitrogen leaching and runoff): $N_2O$” were changed.
10. In consideration of the actual situation regarding “4.B. Manure Management,” $N_2O$ emissions from grazing cattle are now counted under “4.D.2. Pasture, Range and Paddock Manure.”
11. For “4.D.1. Synthetic Fertilizers” and “4.D.2. Organic Fertilizers”, the fertilizer amounts applied to tea were changed from a constant value for all years to annual variable values based on literature which accounts for the actual fertilization practices.
12. $N_2O$ emissions were not counted for “4.D.1. N-fixing Crops”, but they are now calculated.
13. In consideration of the actual state of emissions, a change was made for “4.D.1. Plowing Crop Residue into Soil” from calculations based on the land area cultivated to calculations based on

harvest yield.

14. In “5.B. Cropland” the living biomass amounts for rice fields and crop fields were reset to zero, and therefore the emission and removal amounts from this cropland, or arising in conjunction with a switch to such land use, were recalculated.
15. Activity data changed for “5.C. Grassland”, “5.E. Settlements”, and “5.F. Other Land” because the breakdown of Other Land was specified and reclassified.
16. The calculation method for “5.C.2. Land converted to Grassland” was changed from the post-conversion amount of biomass growth to one that more accurately reflects the actual situation.
17. Owing to the need for a detailed investigation of the soil carbon stock with respect to “5.D. Wetlands”, “5.E. Settlements”, and “5.F. Other Land”, emissions and removals from this land, or arising in conjunction with a switch to such land use, were reported as “NE.”
18. “5(III) $N_2O$ Emissions from Soil Drainage” was reported as “NO” because it was found that the specific activity causing emissions is very rarely conducted.
19. Emissions and removals for “5(IV) $CO_2$ Emissions from Agricultural Lime Application” are now calculated because it became possible to determine activity data.
20. Non-$CO_2$ emissions from biomass burning in conjunction with land conversion in “5(V) Biomass Burning” were reported as “NO” because it was found that the specific activity causing emissions is very rarely conducted.
21. A default oxidation factor (0.1) based on research was set for “6.A.1. Emissions from Controlled Landfill Sites”.
22. change in the calculation method based on the 2006 IPCC Guidelines, emissions in “6.A.3 Emissions from Composting of Organic Waste” are now counted under “6.D Other.”
23. The amount of sewage sludge disposed of at sea was added to “6.B.2.d Emissions from the Natural Decomposition of Domestic Wastewater” using sources such as “Sewerage Statistics, Japan Sewage Works Association”.
24. Emissions from waste incineration in conjunction with energy use and recovery under “6.C Waste Incineration” are now counted under “1.A Fuel Combustion” based on the 1996 Revised IPCC Guidelines and GPG (2000).

#### 10.4.1.2. National Greenhouse Gas Inventory Report

1. In FY 2008, the QA/QC plan was revised by taking the Expert Review Team’s recommendations into consideration. According to the revise, additions were made to “Chapter 1, 1.6 QA/QC Plan.”
2. An analysis of 1990 key categories was added to “Annex 1. Key Categories.”
3. A complete revision on the enhancement of the QA/QC Plan was made to “Annex 6. Additional Information to be Considered as Part of the NIR Submission or Other Useful Reference Information.”

### 10.4.2. Planned Improvements

The main planned improvements are as follows.

1. Review of estimation methods, activity data, emission factors and other elements

   Japan will hold meetings of a Committee for Greenhouse Gas Emission Estimation Methods and will consider improvements of estimation methods, activity data, emission factors and other elements used in the current inventory. When it will implement the consideration, Japan will prioritize 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.

# Annex 1. Key Categories

## 1.1. 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 *Good Practice Guidance (2000)* and identify the key categories.

The key category analyses were done for both data of FY 2007 and of FY 1990, the base year for the UNFCCC[3]. Their results are presented here.

## 1.2. Results of Key Category Analysis

### 1.2.1. Key Categories

Key categories were assessed in accordance with the *Good Practice Guidance (2000)* 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 *LULUCF-GPG*. 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, 37 and 33 sources and sinks were detected as the key source categories for FY 2007 and FY 1990, respectively (Table 1 and 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 latest UNFCCC reporting guidelines (FCCC/SBSTA/2004/8), the term “key source category” was revised to “key category”.

3 With respect to HFCs、PFCs、$SF_6$, the data used for this analysis were the FY 1995 values.

Table 1 Japan's Key Categories (FY 2007)

| | A<br>IPCC Category | | B<br>Direct GHGs | L1 | T1 | L2 | T2 |
|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Solid Fuels | $CO_2$ | #1 | #2 | #3 | #7 |
| #2 | 1A Stationary Combustion | Liquid Fuels | $CO_2$ | #2 | #1 | #8 | #8 |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | $CO_2$ | #3 | #5 | #4 | |
| #4 | 1A Stationary Combustion | Gaseous Fuels | $CO_2$ | #4 | #3 | | |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | $CO_2$ | #5 | | #6 | |
| #6 | 2A Mineral Product | 1. Cement Production | $CO_2$ | #6 | #6 | #7 | #11 |
| #7 | 1A Stationary Combustion | Other Fuels | $CO_2$ | #7 | #11 | #14 | #14 |
| #8 | 6C Waste Incineration | | $CO_2$ | #8 | | #2 | #21 |
| #9 | 1A3 Mobile Combustion | d. Navigation | $CO_2$ | #9 | | | |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | $CO_2$ | #10 | | #13 | |
| #11 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 1. Refrigeration and Air Conditioning | HFCs | #11 | #8 | #5 | #2 |
| #12 | 1A3 Mobile Combustion | a. Civil Aviation | $CO_2$ | #12 | #15 | | |
| #13 | 2A Mineral Product | 2. Lime Production | $CO_2$ | #13 | | #22 | |
| #14 | 4A Enteric Fermentation | | $CH_4$ | | | #25 | |
| #15 | 4C Rice Cultivation | | $CH_4$ | | | #19 | #22 |
| #16 | 4B Manure Management | | $N_2O$ | | | #12 | #20 |
| #17 | 1A Stationary Combustion | | $N_2O$ | | | #18 | #17 |
| #18 | 6A Solid Waste Disposal on Land | | $CH_4$ | | #13 | #20 | #9 |
| #19 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | | | #10 | |
| #20 | 4D Agricultural Soils | 1. Direct Soil Emissions | $N_2O$ | | | #9 | #12 |
| #21 | 4D Agricultural Soils | 3. Indirect Emissions | $N_2O$ | | | #15 | #18 |
| #22 | 1A3 Mobile Combustion | b. Road Transportation | $N_2O$ | | | #16 | #10 |
| #23 | 4B Manure Management | | $CH_4$ | | | #17 | #19 |
| #24 | 6C Waste Incineration | | $N_2O$ | | | #11 | #16 |
| #25 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 5. Solvents | PFCs | | #9 | | #4 |
| #26 | 5E Settlements | 2. Land converted to Settlements | $CO_2$ | | #18 | | #25 |
| #27 | 5A Forest Land | 2. Land converted to Forest Land | $CO_2$ | | #12 | | |
| #28 | 2E Production of Halocarbons and | 2. Fugitive Emissions | $SF_6$ | | #14 | #21 | #3 |
| #29 | 6B Wastewater Handling | | $N_2O$ | | | #23 | |
| #30 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | $SF_6$ | | #7 | | #1 |
| #31 | 2E Production of Halocarbons and | 2. Fugitive Emissions | PFCs | | | #26 | |
| #32 | 2B Chemical Industry | 3. Adipic Acid | $N_2O$ | | #10 | | #15 |
| #33 | 5B Cropland | 2. Land converted to Cropland | $CO_2$ | | | | #24 |
| #34 | 2E Production of Halocarbons and $SF_6$ | 1. By-product Emissions (Production of HCFC-22) | HFCs | | #4 | | #13 |
| #35 | 1A3 Mobile Combustion | a. Civil Aviation | $N_2O$ | | | #1 | #5 |
| #36 | 1A3 Mobile Combustion | d. Navigation | $N_2O$ | | | #24 | |
| #37 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under gr.) | $CH_4$ | | #16 | | #6 |

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

Table 2 Japan's Key Categories (FY 1990)

| | A IPCC Category | | B Direct GHGs | L1 | L2 |
|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Liquid Fuels | $CO_2$ | #1 | #8 |
| #2 | 1A Stationary Combustion | Solid Fuels | $CO_2$ | #2 | #4 |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | $CO_2$ | #3 | #6 |
| #4 | 1A Stationary Combustion | Gaseous Fuels | $CO_2$ | #4 | |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | $CO_2$ | #5 | #7 |
| #6 | 2A Mineral Product | 1. Cement Production | $CO_2$ | #6 | #10 |
| #7 | 2E Production of Halocarbons and $SF_6$ | 1. By-product Emissions (Production of HCFC-22) | HFCs | #7 | #26 |
| #8 | 1A3 Mobile Combustion | d. Navigation | $CO_2$ | #8 | |
| #9 | 6C Waste Incineration | | $CO_2$ | #9 | #2 |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | $CO_2$ | #10 | #19 |
| #11 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 8. Electrical Equipment | $SF_6$ | #11 | #5 |
| #12 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 5. Solvents | PFCs | #12 | #9 |
| #13 | 1A Stationary Combustion | Other Fuels | $CO_2$ | #13 | #25 |
| #14 | 6A Solid Waste Disposal on Land | | $CH_4$ | #14 | #15 |
| #15 | 4A Enteric Fermentation | | $CH_4$ | #15 | #28 |
| #16 | 2B Chemical Industry | 3. Adipic Acid | $N_2O$ | #16 | |
| #17 | 2A Mineral Product | 2. Lime Production | $CO_2$ | #17 | #23 |
| #18 | 1A3 Mobile Combustion | a. Civil Aviation | $CO_2$ | #18 | |
| #19 | 4C Rice Cultivation | | $CH_4$ | | #20 |
| #20 | 4B Manure Management | | $N_2O$ | | #14 |
| #21 | 2E Production of Halocarbons and $SF_6$ | 2. Fugitive Emissions | $SF_6$ | | #3 |
| #22 | 4D Agricultural Soils | 1. Direct Soil Emissions | $N_2O$ | | #11 |
| #23 | 1A3 Mobile Combustion | b. Road Transportation | $N_2O$ | | #13 |
| #24 | 4D Agricultural Soils | 3. Indirect Emissions | $N_2O$ | | #16 |
| #25 | 2F(a) Consumption of Halocarbons and $SF_6$ (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | | #17 |
| #26 | 4B Manure Management | | $CH_4$ | | #18 |
| #27 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under gr.) | $CH_4$ | | #12 |
| #28 | 6B Wastewater Handling | | $CH_4$ | | #27 |
| #29 | 6C Waste Incineration | | $N_2O$ | | #21 |
| #30 | 6B Wastewater Handling | | $N_2O$ | | #22 |
| #31 | 2B Chemical Industry | Other products except Anmonia | $CO_2$ | | #29 |
| #32 | 1A3 Mobile Combustion | d. Navigation | $N_2O$ | | #24 |
| #33 | 1A3 Mobile Combustion | a. Civil Aviation | $N_2O$ | | #1 |

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

The data of HFCs, PFCs and $SF_6$ utilized for this analysis are the 1995 values.

### 1.2.2. 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 *LULUCF-GPG* (p.5.30), 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 (FY 2007) gives the following 13 sub-categories as the key categories (Table 3). Tier 2 level assessment of the latest emissions and removals (FY 2007) gives the following 26 sub-categories as the key categories (Table 4).

Table 3 Results of Tier 1 Level Assessment (FY 2007)

| | A IPCC Category | | B Direct GHGs | D Current Year Estimate [Gg CO2 eq.] | E Level Assessment | F % Contribution to Level | Cumulative |
|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Solid Fuels | CO2 | 451,893.02 | 0.309 | 30.9% | 30.9% |
| #2 | 1A Stationary Combustion | Liquid Fuels | CO2 | 322,477.35 | 0.221 | 22.1% | 53.0% |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 217,652.78 | 0.149 | 14.9% | 67.9% |
| #4 | 1A Stationary Combustion | Gaseous Fuels | CO2 | 203,287.27 | 0.139 | 13.9% | 81.8% |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 81,595.45 | 0.056 | 5.6% | 87.4% |
| #6 | 2A Mineral Product | 1. Cement Production | CO2 | 30,076.22 | 0.021 | 2.1% | 89.4% |
| #7 | 1A Stationary Combustion | Other Fuels | CO2 | 15,982.70 | 0.011 | 1.1% | 90.5% |
| #8 | 6C Waste Incineration | | CO2 | 14,226.64 | 0.010 | 1.0% | 91.5% |
| #9 | 1A3 Mobile Combustion | d. Navigation | CO2 | 12,411.48 | 0.008 | 0.8% | 92.4% |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 12,003.50 | 0.008 | 0.8% | 93.2% |
| #11 | 2F(a) Consumption of Halocarbons | 1. Refrigeration and Air Conditioning Equipment | HFCs | 11,375.49 | 0.008 | 0.8% | 94.0% |
| #12 | 1A3 Mobile Combustion | a. Civil Aviation | CO2 | 10,875.77 | 0.007 | 0.7% | 94.7% |
| #13 | 2A Mineral Product | 2. Lime Production | CO2 | 7,799.26 | 0.005 | 0.5% | 95.2% |

Table 4 Results of Tier 2 Level Assessment (FY 2007)

| | Category Code | A IPCC Category | | B Direct GHGs | D Current Year Estimate [Gg CO2 eq.] | I Source/Sink Uncertinty | K Contribution to Total L2 | Cumulative |
|---|---|---|---|---|---|---|---|---|
| #1 | A-17 | 1A3 Mobile Combustion | a. Civil Aviation | N2O | 109.11 | 10000% | 0.13 | 13.0% |
| #2 | F-04 | 6C Waste Incineration | | CO2 | 14,226.64 | 50% | 0.08 | 21.4% |
| #3 | A-02 | 1A Stationary Combustion | Solid Fuels | CO2 | 451,893.02 | 1% | 0.08 | 29.4% |
| #4 | A-10 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 217,652.78 | 2% | 0.06 | 35.3% |
| #5 | B-20 | 2F(a) Consumption of Halocarbons | 1. Refrigeration and Air Conditioning | HFCs | 11,375.49 | 42% | 0.06 | 41.0% |
| #6 | E-01 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 81,595.45 | 6% | 0.06 | 46.6% |
| #7 | B-01 | 2A Mineral Product | 1. Cement Production | CO2 | 30,076.22 | 10% | 0.04 | 50.3% |
| #8 | A-01 | 1A Stationary Combustion | Liquid Fuels | CO2 | 322,477.35 | 1% | 0.04 | 54.0% |
| #9 | D-05 | 4D Agricultural Soils | 1. Direct Soil Emissions | N2O | 3,348.49 | 90% | 0.04 | 57.6% |
| #10 | B-26 | 2F(a) Consumption of Halocarbons | 7. Semiconductor Manufacture | PFCs | 3,741.32 | 64% | 0.03 | 60.5% |
| #11 | F-06 | 6C Waste Incineration | | N2O | 2,296.09 | 103% | 0.03 | 63.3% |
| #12 | D-03 | 4B Manure Management | | N2O | 4,860.72 | 48% | 0.03 | 66.1% |
| #13 | B-03 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 12,003.50 | 17% | 0.02 | 68.4% |
| #14 | A-04 | 1A Stationary Combustion | Other Fuels | CO2 | 15,982.70 | 12% | 0.02 | 70.8% |
| #15 | D-07 | 4D Agricultural Soils | 3. Indirect Emissions | N2O | 2,976.80 | 64% | 0.02 | 73.0% |
| #16 | A-18 | 1A3 Mobile Combustion | b. Road Transportation | N2O | 2,490.03 | 71% | 0.02 | 75.1% |
| #17 | D-02 | 4B Manure Management | | CH4 | 2,394.07 | 64% | 0.02 | 76.9% |
| #18 | A-06 | 1A Stationary Combustion | | N2O | 4,564.73 | 33% | 0.02 | 78.7% |
| #19 | D-04 | 4C Rice Cultivation | | CH4 | 5,654.25 | 23% | 0.02 | 80.3% |
| #20 | F-01 | 6A Solid Waste Disposal on Land | | CH4 | 4,516.93 | 29% | 0.02 | 81.8% |
| #21 | B-19 | 2E Production of Halocarbons | 2. Fugitive Emissions | SF6 | 1,270.43 | 100% | 0.02 | 83.3% |
| #22 | B-02 | 2A Mineral Product | 2. Lime Production | CO2 | 7,799.26 | 16% | 0.01 | 84.8% |
| #23 | F-03 | 6B Wastewater Handling | | N2O | 1,159.00 | 93% | 0.01 | 86.0% |
| #24 | A-20 | 1A3 Mobile Combustion | d. Navigation | N2O | 101.42 | 1000% | 0.01 | 87.2% |
| #25 | D-01 | 4A Enteric Fermentation | | CH4 | 7,120.61 | 12% | 0.01 | 88.2% |
| #26 | B-18 | 2E Production of Halocarbons | 2. Fugitive Emissions | PFCs | 783.02 | 100% | 0.01 | 89.2% |
| #27 | B-24 | 2F(a) Consumption of Halocarbons | 5. Solvents | PFCs | 1,944.38 | 40% | 0.01 | 90.1% |

Tier 1 level assessment of the latest emissions and removals (FY 1990) gives the following 18 sub-categories as the key categories (Table 5). Tier 2 level assessment of the latest emissions and removals (FY 1990) gives the following 29 sub-categories as the key categories (Table 6).

Table 5 Results of Tier 1 Level Assessment (FY 1990)

| | A IPCC Category | | B Direct GHGs | C Base Year Estimate [Gg CO2 eq.] | E kevek Assessment | F % Contribution to Level | Cumulative |
|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Liquid Fuels | CO2 | 435,168.99 | 0.323 | 32.3% | 32.3% |
| #2 | 1A Stationary Combustion | Solid Fuels | CO2 | 308,620.23 | 0.229 | 22.9% | 55.2% |
| #3 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 189,227.88 | 0.140 | 14.0% | 69.2% |
| #4 | 1A Stationary Combustion | Gaseous Fuels | CO2 | 104,300.83 | 0.077 | 7.7% | 76.9% |
| #5 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 75,127.14 | 0.056 | 5.6% | 82.5% |
| #6 | 2A Mineral Product | 1. Cement Production | CO2 | 37,966.28 | 0.028 | 2.8% | 85.3% |
| #7 | 2E Production of Halocarbons and SF6 | 1. By-product Emissions (Production of HCFC-22) | HFCs | 16,965.00 | 0.013 | 1.3% | 86.6% |
| #8 | 1A3 Mobile Combustion | d. Navigation | CO2 | 13,730.95 | 0.010 | 1.0% | 87.6% |
| #9 | 6C Waste Incineration | | CO2 | 12,173.71 | 0.009 | 0.9% | 88.5% |
| #10 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 11,527.41 | 0.009 | 0.9% | 89.3% |
| #11 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | SF6 | 11,004.99 | 0.008 | 0.8% | 90.2% |
| #12 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 5. Solvents | PFCs | 10,382.05 | 0.008 | 0.8% | 90.9% |
| #13 | 1A Stationary Combustion | Other Fuels | CO2 | 8,875.30 | 0.007 | 0.7% | 91.6% |
| #14 | 6A Solid Waste Disposal on Land | | CH4 | 8,285.86 | 0.006 | 0.6% | 92.2% |
| #15 | 4A Enteric Fermentation | | CH4 | 7,674.46 | 0.006 | 0.6% | 92.8% |
| #16 | 2B Chemical Industry | 3. Adipic Acid | N2O | 7,501.25 | 0.006 | 0.6% | 93.3% |
| #17 | 2A Mineral Product | 2. Lime Production | CO2 | 7,321.64 | 0.005 | 0.5% | 93.9% |
| #18 | 1A3 Mobile Combustion | a. Civil Aviation | CO2 | 7,162.41 | 0.005 | 0.5% | 94.4% |
| #19 | 4C Rice Cultivation | | CH4 | 7,002.78 | 0.005 | 0.5% | 94.9% |
| #20 | 4B Manure Management | | N2O | 5,661.40 | 0.004 | 0.4% | 95.3% |

Table 6 Results of Tier 2 Level Assessment (FY 1990)

| | A IPCC Category | | B Direct GHGs | C Base Year Estimate [Gg CO2eq.] | I Source/Sink Uncertinty | K Contribution to Total L2 | Cumulative |
|---|---|---|---|---|---|---|---|
| #1 | 1A3 Mobile Combustion | a. Civil Aviation | N2O | 69.75 | 10000% | 0.08 | 7.5% |
| #2 | 6C Waste Incineration | | CO2 | 12,173.71 | 50% | 0.07 | 14.0% |
| #3 | 2E Production of Halocarbons | 2. Fugitive Emissions | SF6 | 4,708.30 | 100% | 0.05 | 19.1% |
| #4 | 1A Stationary Combustion | Solid Fuels | CO2 | 308,620.23 | 1% | 0.05 | 24.1% |
| #5 | 2F(a) Consumption of Halocarbons | 8. Electrical Equipment | SF6 | 11,004.99 | 40% | 0.05 | 28.9% |
| #6 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 189,227.88 | 2% | 0.05 | 33.6% |
| #7 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 75,127.14 | 6% | 0.05 | 38.2% |
| #8 | 1A Stationary Combustion | Liquid Fuels | CO2 | 435,168.99 | 1% | 0.05 | 42.8% |
| #9 | 2F(a) Consumption of Halocarbons | 5. Solvents | PFCs | 10,382.05 | 40% | 0.04 | 47.2% |
| #10 | 2A Mineral Product | 1. Cement Production | CO2 | 37,966.28 | 10% | 0.04 | 51.5% |
| #11 | 4D Agricultural Soils | 1. Direct Soil Emissions | N2O | 4,249.46 | 90% | 0.04 | 55.6% |
| #12 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under | CH4 | 2,785.23 | 107% | 0.03 | 58.8% |
| #13 | 1A3 Mobile Combustion | b. Road Transportation | N2O | 3,901.71 | 71% | 0.03 | 61.8% |
| #14 | 4B Manure Management | | N2O | 5,661.40 | 48% | 0.03 | 64.7% |
| #15 | 6A Solid Waste Disposal on Land | | CH4 | 8,285.86 | 29% | 0.03 | 67.3% |
| #16 | 4D Agricultural Soils | 3. Indirect Emissions | N2O | 3,669.26 | 64% | 0.03 | 69.8% |
| #17 | 2F(a) Consumption of Halocarbons | 7. Semiconductor Manufacture | PFCs | 3,148.83 | 64% | 0.02 | 72.0% |
| #18 | 4B Manure Management | | CH4 | 3,104.72 | 64% | 0.02 | 74.1% |
| #19 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 11,527.41 | 17% | 0.02 | 76.2% |
| #20 | 4C Rice Cultivation | | CH4 | 7,002.78 | 23% | 0.02 | 77.9% |
| #21 | 6C Waste Incineration | | N2O | 1,517.74 | 103% | 0.02 | 79.6% |
| #22 | 6B Wastewater Handling | | N2O | 1,289.65 | 93% | 0.01 | 80.9% |
| #23 | 2A Mineral Product | 2. Lime Production | CO2 | 7,321.64 | 16% | 0.01 | 82.1% |
| #24 | 1A3 Mobile Combustion | d. Navigation | N2O | 111.31 | 1000% | 0.01 | 83.3% |
| #25 | 1A Stationary Combustion | Other Fuels | CO2 | 8,875.30 | 12% | 0.01 | 84.5% |
| #26 | 2E Production of Halocarbons | 1. By-product Emissions | HFCs | 16,965.00 | 5% | 0.01 | 85.5% |
| #27 | 6B Wastewater Handling | | CH4 | 2,120.57 | 43% | 0.01 | 86.5% |
| #28 | 4A Enteric Fermentation | | CH4 | 7,674.46 | 12% | 0.01 | 87.4% |
| #29 | 2B Chemical Industry | other products except Anmonia | CO2 | 1,129.29 | 77% | 0.01 | 88.4% |
| #30 | 2B Chemical Industry | 1. Ammonia Production | CO2 | 3,384.68 | 23% | 0.01 | 89.2% |
| #31 | 1A Stationary Combustion | | N2O | 2,332.05 | 33% | 0.01 | 90.1% |
| #32 | 2E Production of Halocarbons | 2. Fugitive Emissions | PFCs | 762.85 | 100% | 0.01 | 90.9% |

### 1.2.3. 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 *LULUCF-GPG* (p.5.30), 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 (FY 2007) gives the following 17 sub-categories as the key categories (Table 7). Tier 2 trend assessment of the latest emissions and removals (FY 2007) gives the following 24 sub-categories as the key categories (Table 8).

Table 7 Results of Tier 1 Trend Assessment (FY 2007)

| | A<br>IPCC Category | | B<br>Direct GHGs | C<br>Base Year Estimate [Gg CO2 eq.] | D<br>Current Year Estimate [Gg CO2 eq.] | H<br>% Contribution to Trend | Cumulative |
|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Liquid Fuels | CO2 | 435169 | 322477 | 30.3% | 30.3% |
| #2 | 1A Stationary Combustion | Solid Fuels | CO2 | 308620 | 451893 | 23.9% | 54.2% |
| #3 | 1A Stationary Combustion | Gaseous Fuels | CO2 | 104301 | 203287 | 18.3% | 72.5% |
| #4 | 2E Production of Halocarbons and SF6 | 1. By-product Emissions (Production of HCFC-22) | HFCs | 16965 | 218 | 3.7% | 76.2% |
| #5 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 189228 | 217653 | 2.6% | 78.8% |
| #6 | 2A Mineral Product | 1. Cement Production | CO2 | 37966 | 30076 | 2.2% | 81.0% |
| #7 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | SF6 | 11005 | 922 | 2.2% | 83.2% |
| #8 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 1. Refrigeration and Air Conditioning Equipment | HFCs | 840 | 11375 | 2.1% | 85.4% |
| #9 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 5. Solvents | PFCs | 10382 | 1944 | 1.9% | 87.3% |
| #10 | 2B Chemical Industry | 3. Adipic Acid | N2O | 7501 | 271 | 1.6% | 88.9% |
| #11 | 1A Stationary Combustion | Other Fuels | CO2 | 8875 | 15983 | 1.3% | 90.1% |
| #12 | 5A Forest Land | 2. Land converted to Forest Land | CO2 | 5651 | 1272 | 1.0% | 91.1% |
| #13 | 6A Solid Waste Disposal on Land | | CH4 | 8286 | 4517 | 0.9% | 92.0% |
| #14 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | SF6 | 4708 | 1270 | 0.8% | 92.8% |
| #15 | 1A3 Mobile Combustion | a. Civil Aviation | CO2 | 7162 | 10876 | 0.6% | 93.4% |
| #16 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under | CH4 | 2785 | 40 | 0.6% | 94.1% |
| #17 | 1A3 Mobile Combustion | d. Navigation | CO2 | 13731 | 12411 | 0.5% | 94.6% |
| #18 | 5E Settlements | 2. Land converted to Settlements | CO2 | 3548 | 1526 | 0.5% | 95.0% |

Table 8 Results of Tier 2 Trend Assessment (FY 2007)

| | A<br>IPCC Category | | B<br>Direct GHGs | C<br>Base Year Estimate [Gg CO2 eq.] | D<br>Current Year Estimate [Gg CO2 eq.] | I<br>Source/Sink Uncertainty | M<br>Contribution to Total T2 | Cumulative |
|---|---|---|---|---|---|---|---|---|
| #1 | 2F(a) Consumption of Halocarbons | 8. Electrical Equipment | SF6 | 11,004.99 | 922.41 | 40% | 0.10 | 10.3% |
| #2 | 2F(a) Consumption of Halocarbons | 1. Refrigeration and Air Conditioning | HFCs | 840.40 | 11,375.49 | 42% | 0.10 | 20.5% |
| #3 | 2E Production of Halocarbons | 2. Fugitive Emissions | SF6 | 4,708.30 | 1,270.43 | 100% | 0.09 | 29.5% |
| #4 | 2F(a) Consumption of Halocarbons | 5. Solvents | PFCs | 10,382.05 | 1,944.38 | 40% | 0.09 | 38.1% |
| #5 | 1A3 Mobile Combustion | a. Civil Aviation | N2O | 69.75 | 109.11 | 10000% | 0.08 | 45.9% |
| #6 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under | CH4 | 2,785.23 | 39.82 | 107% | 0.07 | 53.3% |
| #7 | 1A Stationary Combustion | Solid Fuels | CO2 | 308,620.23 | 451,893.02 | 1% | 0.04 | 57.4% |
| #8 | 1A Stationary Combustion | Liquid Fuels | CO2 | 435,168.99 | 322,477.35 | 1% | 0.03 | 60.7% |
| #9 | 6A Solid Waste Disposal on Land | | CH4 | 8,285.86 | 4,516.93 | 29% | 0.03 | 63.7% |
| #10 | 1A3 Mobile Combustion | b. Road Transportation | N2O | 3,901.71 | 2,490.03 | 71% | 0.03 | 66.5% |
| #11 | 2A Mineral Product | 1. Cement Production | CO2 | 37,966.28 | 30,076.22 | 10% | 0.03 | 69.2% |
| #12 | 4D Agricultural Soils | 1. Direct Soil Emissions | N2O | 4,249.46 | 3,348.49 | 90% | 0.03 | 71.9% |
| #13 | 2E Production of Halocarbons | 1. By-product Emissions | HFCs | 16,965.00 | 217.62 | 5% | 0.02 | 74.1% |
| #14 | 1A Stationary Combustion | Other Fuels | CO2 | 8,875.30 | 15,982.70 | 12% | 0.02 | 76.0% |
| #15 | 2B Chemical Industry | 3. Adipic Acid | N2O | 7,501.25 | 270.91 | 9% | 0.02 | 77.6% |
| #16 | 6C Waste Incineration | | N2O | 1,517.74 | 2,296.09 | 103% | 0.02 | 79.2% |
| #17 | 1A Stationary Combustion | | N2O | 2,332.05 | 4,564.73 | 33% | 0.02 | 80.8% |
| #18 | 4D Agricultural Soils | 3. Indirect Emissions | N2O | 3,669.26 | 2,976.80 | 64% | 0.01 | 82.3% |
| #19 | 4B Manure Management | | CH4 | 3,104.72 | 2,394.07 | 64% | 0.01 | 83.7% |
| #20 | 4B Manure Management | | N2O | 5,661.40 | 4,860.72 | 48% | 0.01 | 85.1% |
| #21 | 6C Waste Incineration | | CO2 | 12,173.71 | 14,226.64 | 50% | 0.01 | 86.3% |
| #22 | 4C Rice Cultivation | | CH4 | 7,002.78 | 5,654.25 | 23% | 0.01 | 87.3% |
| #23 | 6B Wastewater Handling | | CH4 | 2,120.57 | 1,369.21 | 43% | 0.01 | 88.3% |
| #24 | 5B Cropland | 2. Land converted to Cropland | CO2 | 2,057.84 | 265.44 | 17% | 0.01 | 89.1% |
| #25 | 5E Settlements | 2. Land converted to Settlements | CO2 | 3,548.45 | 1,526.38 | 15% | 0.01 | 89.8% |
| #26 | 2B Chemical Industry | 1. Ammonia Production | CO2 | 3,384.68 | 2,296.03 | 23% | 0.01 | 90.6% |

Data utilized for the key category analysis are shown in Table 9 and 10 as references.

## Table 9 Data used for the key category analysis (FY 2007)

| | A IPCC Category | | B Direct GHGs | C Base Year 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 Uncertinty | 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 | 435,168.99 | 322,477.35 | 0.221 | 22.1% | 0.0941 | 30.3% | 1% | 2.13 | 0.04 | 0.91 | 0.03 |
| #2 | 1A Stationary Combustion | Solid Fuels | CO2 | 308,620.23 | 451,893.02 | 0.309 | 30.9% | 0.0742 | 23.9% | 1% | 4.64 | 0.08 | 1.11 | 0.04 |
| #3 | 1A Stationary Combustion | Gaseous Fuels | CO2 | 104,300.83 | 203,287.27 | 0.139 | 13.9% | 0.0570 | 18.3% | 0% | 0.41 | 0.01 | 0.17 | 0.01 |
| #4 | 1A Stationary Combustion | Other Fuels | CO2 | 8,875.30 | 15,982.70 | 0.011 | 1.1% | 0.0040 | 1.3% | 12% | 1.36 | 0.02 | 0.50 | 0.02 |
| #5 | 1A Stationary Combustion | | CH4 | 533.48 | 574.39 | 0.000 | 0.0% | 0.0000 | 0.0% | 47% | 0.18 | 0.00 | 0.00 | 0.00 |
| #6 | 1A Stationary Combustion | | N2O | 2,332.05 | 4,564.73 | 0.003 | 0.3% | 0.0013 | 0.4% | 33% | 1.03 | 0.02 | 0.42 | 0.02 |
| #7 | 1A Stationary Combustion | | CH4 | 50.77 | 85.63 | 0.000 | 0.0% | 0.0000 | 0.0% | 105% | 0.06 | 0.00 | 0.02 | 0.00 |
| #8 | 1A Stationary Combustion | | N2O | 387.23 | 594.42 | 0.000 | 0.0% | 0.0001 | 0.0% | 37% | 0.15 | 0.00 | 0.04 | 0.00 |
| #9 | 1A3 Mobile Combustion | a. Civil Aviation | CO2 | 7,162.41 | 10,875.77 | 0.007 | 0.7% | 0.0020 | 0.6% | 3% | 0.19 | 0.00 | 0.05 | 0.00 |
| #10 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 189,227.88 | 217,652.78 | 0.149 | 14.9% | 0.0080 | 2.6% | 2% | 3.43 | 0.06 | 0.18 | 0.01 |
| #11 | 1A3 Mobile Combustion | c. Railways | CO2 | 932.45 | 647.04 | 0.000 | 0.0% | 0.0002 | 0.1% | 2% | 0.01 | 0.00 | 0.01 | 0.00 |
| #12 | 1A3 Mobile Combustion | d. Navigation | CO2 | 13,730.95 | 12,411.48 | 0.008 | 0.8% | 0.0016 | 0.5% | 2% | 0.20 | 0.00 | 0.04 | 0.00 |
| #13 | 1A3 Mobile Combustion | a. Civil Aviation | CH4 | 2.94 | 4.84 | 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 | 266.66 | 179.32 | 0.000 | 0.0% | 0.0001 | 0.0% | 64% | 0.08 | 0.00 | 0.04 | 0.00 |
| #15 | 1A3 Mobile Combustion | c. Railways | CH4 | 1.18 | 0.80 | 0.000 | 0.0% | 0.0000 | 0.0% | 14% | 0.00 | 0.00 | 0.00 | 0.00 |
| #16 | 1A3 Mobile Combustion | d. Navigation | CH4 | 26.33 | 24.26 | 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 | 109.11 | 0.000 | 0.0% | 0.0000 | 0.0% | 10000% | 7.47 | 0.13 | 2.12 | 0.08 |
| #18 | 1A3 Mobile Combustion | b. Road Transportation | N2O | 3,901.71 | 2,490.03 | 0.002 | 0.2% | 0.0011 | 0.4% | 71% | 1.20 | 0.02 | 0.78 | 0.03 |
| #19 | 1A3 Mobile Combustion | c. Railways | N2O | 121.38 | 82.77 | 0.000 | 0.0% | 0.0000 | 0.0% | 11% | 0.01 | 0.00 | 0.00 | 0.00 |
| #20 | 1A3 Mobile Combustion | d. Navigation | N2O | 111.31 | 101.42 | 0.000 | 0.0% | 0.0000 | 0.0% | 1000% | 0.69 | 0.01 | 0.12 | 0.00 |
| #21 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under | CH4 | 2,785.23 | 39.82 | 0.000 | 0.0% | 0.0019 | 0.6% | 107% | 0.03 | 0.00 | 2.01 | 0.07 |
| #22 | 1B Fugitive Emission | 1a ii. Coal Mining and Handling | CH4 | 21.20 | 11.65 | 0.000 | 0.0% | 0.0000 | 0.0% | 185% | 0.01 | 0.00 | 0.01 | 0.00 |
| #23 | 1B Fugitive Emission | 2a. Oil | CO2 | 0.14 | 0.11 | 0.000 | 0.0% | 0.0000 | 0.0% | 21% | 0.00 | 0.00 | 0.00 | 0.00 |
| #24 | 1B Fugitive Emission | 2a. Oil | CH4 | 28.32 | 28.23 | 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 | 0.46 | 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 | 324.23 | 0.000 | 0.0% | 0.0001 | 0.0% | 23% | 0.05 | 0.00 | 0.02 | 0.00 |
| #28 | 1B Fugitive Emission | 2c. Venting & Flaring | CO2 | 36.23 | 36.96 | 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 | 12.55 | 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 | 0.12 | 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 | 37,966.28 | 30,076.22 | 0.021 | 2.1% | 0.0070 | 2.2% | 10% | 2.15 | 0.04 | 0.73 | 0.03 |
| #32 | 2A Mineral Product | 2. Lime Production | CO2 | 7,321.64 | 7,799.26 | 0.005 | 0.5% | 0.0001 | 0.0% | 16% | 0.84 | 0.01 | 0.01 | 0.00 |
| #33 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 11,527.41 | 12,003.50 | 0.008 | 0.8% | 0.0003 | 0.1% | 17% | 1.36 | 0.02 | 0.05 | 0.00 |
| #34 | 2A Mineral Product | 4. Soda Ash Production and Use | CO2 | 583.63 | 339.98 | 0.000 | 0.0% | 0.0002 | 0.1% | 16% | 0.04 | 0.00 | 0.03 | 0.00 |
| #35 | 2B Chemical Industry | 1. Ammonia Production | CO2 | 3,384.68 | 2,296.03 | 0.002 | 0.2% | 0.0009 | 0.3% | 23% | 0.36 | 0.01 | 0.20 | 0.01 |
| #36 | 2B Chemical Industry | other products except Anmonia | CO2 | 1,129.29 | 1,002.83 | 0.001 | 0.1% | 0.0001 | 0.0% | 77% | 0.53 | 0.01 | 0.11 | 0.00 |
| #37 | 2B Chemical Industry | 2. Nitric Acid | N2O | 765.70 | 589.27 | 0.000 | 0.0% | 0.0002 | 0.0% | 46% | 0.19 | 0.00 | 0.07 | 0.00 |
| #38 | 2B Chemical Industry | 3. Adipic Acid | N2O | 7,501.25 | 270.91 | 0.000 | 0.0% | 0.0050 | 1.6% | 9% | 0.02 | 0.00 | 0.46 | 0.02 |
| #39 | 2B Chemical Industry | 4. Carbide Production | CH4 | 0.42 | 0.66 | 0.000 | 0.0% | 0.0000 | 0.0% | 100% | 0.00 | 0.00 | 0.00 | 0.00 |
| #40 | 2B Chemical Industry | 5. Carbon Black, Ethylene, Ethylene Dichloride, Styrene, Methanol, Coke | CH4 | 337.80 | 115.85 | 0.000 | 0.0% | 0.0002 | 0.1% | 89% | 0.07 | 0.00 | 0.14 | 0.01 |
| #41 | 2C Metal Production | 1 Iron and Steel Production | CO2 | 356.09 | 212.02 | 0.000 | 0.0% | 0.0001 | 0.0% | 5% | 0.01 | 0.00 | 0.00 | 0.00 |
| #42 | 2C Metal Production | 1 Iron and Steel Production | CH4 | 15.47 | 14.97 | 0.000 | 0.0% | 0.0000 | 0.0% | 163% | 0.02 | 0.00 | 0.00 | 0.00 |
| #43 | 2C Metal Production | 2. Ferroalloys Production | CH4 | 3.89 | 2.33 | 0.000 | 0.0% | 0.0000 | 0.0% | 163% | 0.00 | 0.00 | 0.00 | 0.00 |
| #44 | 2C Metal Production | 3. Aluminium Production | PFCs | 69.74 | 14.69 | 0.000 | 0.0% | 0.0000 | 0.0% | 33% | 0.00 | 0.00 | 0.01 | 0.00 |
| #45 | 2C Metal Production | 4. SF6 Used in Aluminium and Magnesium oundries | SF6 | 119.50 | 996.13 | 0.001 | 0.1% | 0.0005 | 0.2% | 5% | 0.03 | 0.00 | 0.03 | 0.00 |
| #46 | 2E Production of Halocarbons and SF6 | 1. By-product Emissions (Production of HCFC-22) | HFCs | 16,965.00 | 217.62 | 0.000 | 0.0% | 0.0115 | 3.7% | 5% | 0.01 | 0.00 | 0.62 | 0.02 |
| #47 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | HFCs | 480.12 | 279.99 | 0.000 | 0.0% | 0.0002 | 0.0% | 100% | 0.19 | 0.00 | 0.15 | 0.01 |
| #48 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | PFCs | 762.85 | 783.02 | 0.001 | 0.1% | 0.0000 | 0.0% | 100% | 0.54 | 0.01 | 0.03 | 0.00 |
| #49 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | SF6 | 4,708.30 | 1,270.43 | 0.001 | 0.1% | 0.0024 | 0.8% | 100% | 0.87 | 0.02 | 2.43 | 0.09 |
| #50 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 1. Refrigeration and Air Conditioning Equipment | HFCs | 840.40 | 11,375.49 | 0.008 | 0.8% | 0.0066 | 2.1% | 42% | 3.29 | 0.06 | 2.79 | 0.10 |
| #51 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 2. Foam Blowing | HFCs | 451.76 | 316.64 | 0.000 | 0.0% | 0.0001 | 0.0% | 51% | 0.11 | 0.00 | 0.06 | 0.00 |
| #52 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 3. Fire Extinguishers | HFCs | 0.00 | 6.24 | 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 | 1,365.00 | 849.75 | 0.001 | 0.1% | 0.0004 | 0.1% | 31% | 0.18 | 0.00 | 0.12 | 0.00 |
| #54 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 5. Solvents | PFCs | 10,382.05 | 1,944.38 | 0.001 | 0.1% | 0.0059 | 1.9% | 40% | 0.53 | 0.01 | 2.35 | 0.09 |
| #55 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | HFCs | 158.30 | 164.41 | 0.000 | 0.0% | 0.0000 | 0.0% | 64% | 0.07 | 0.00 | 0.00 | 0.00 |
| #56 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | 3,148.83 | 3,741.32 | 0.003 | 0.3% | 0.0002 | 0.1% | 64% | 1.64 | 0.03 | 0.13 | 0.00 |
| #57 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | SF6 | 1,128.98 | 1,196.04 | 0.001 | 0.1% | 0.0000 | 0.0% | 64% | 0.52 | 0.01 | 0.01 | 0.00 |
| #58 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | SF6 | 11,004.99 | 922.41 | 0.001 | 0.1% | 0.0069 | 2.2% | 40% | 0.25 | 0.00 | 2.79 | 0.10 |
| #59 | 3 Solvent & Other Product Use | Using Laughing Gas in Hospital | N2O | 287.07 | 244.76 | 0.000 | 0.0% | 0.0000 | 0.0% | 5% | 0.01 | 0.00 | 0.00 | 0.00 |
| #60 | 4A Enteric Fermentation | | CH4 | 7,674.46 | 7,120.61 | 0.005 | 0.5% | 0.0008 | 0.2% | 12% | 0.57 | 0.01 | 0.09 | 0.00 |
| #61 | 4B Manure Management | | CH4 | 3,104.72 | 2,394.07 | 0.002 | 0.2% | 0.0006 | 0.2% | 64% | 1.05 | 0.02 | 0.39 | 0.01 |
| #62 | 4B Manure Management | | N2O | 5,661.40 | 4,860.72 | 0.003 | 0.3% | 0.0008 | 0.3% | 48% | 1.60 | 0.03 | 0.39 | 0.01 |
| #63 | 4C Rice Cultivation | | CH4 | 7,002.78 | 5,654.25 | 0.004 | 0.4% | 0.0012 | 0.4% | 23% | 0.88 | 0.02 | 0.28 | 0.01 |
| #64 | 4D Agricultural Soils | 1. Direct Soil Emissions | N2O | 4,249.46 | 3,348.49 | 0.002 | 0.2% | 0.0008 | 0.3% | 90% | 2.06 | 0.04 | 0.71 | 0.03 |
| #65 | 4D Agricultural Soils | 2. Pasture, Range and Paddock Manure | N2O | 11.91 | 12.12 | 0.000 | 0.0% | 0.0000 | 0.0% | 133% | 0.01 | 0.00 | 0.00 | 0.00 |
| #66 | 4D Agricultural Soils | 3. Indirect Emissions | N2O | 3,669.26 | 2,976.80 | 0.002 | 0.2% | 0.0006 | 0.2% | 64% | 1.30 | 0.02 | 0.40 | 0.01 |
| #67 | 4F Field Burning of Agricultural | | CH4 | 129.77 | 102.93 | 0.000 | 0.0% | 0.0000 | 0.0% | 142% | 0.10 | 0.00 | 0.03 | 0.00 |
| #68 | 4F Field Burning of Agricultural | | N2O | 103.92 | 76.29 | 0.000 | 0.0% | 0.0000 | 0.0% | 186% | 0.10 | 0.00 | 0.04 | 0.00 |
| #69 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 75,127.14 | 81,595.45 | 0.056 | 5.6% | 0.0001 | 0.0% | 6% | 3.20 | 0.06 | 0.01 | 0.00 |
| #70 | 5A Forest Land | 2. Land converted to Forest Land | CO2 | 5,650.70 | 1,271.57 | 0.001 | 0.1% | 0.0031 | 1.0% | 6% | 0.05 | 0.00 | 0.19 | 0.01 |
| #71 | 5A Forest Land | | CH4 | 8.31 | 1.91 | 0.000 | 0.0% | 0.0000 | 0.0% | 53% | 0.00 | 0.00 | 0.00 | 0.00 |
| #72 | 5A Forest Land | | N2O | 0.84 | 0.19 | 0.000 | 0.0% | 0.0000 | 0.0% | 89% | 0.00 | 0.00 | 0.00 | 0.00 |
| #73 | 5B Cropland | 1. Cropland remaining Cropland | CO2 | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #74 | 5B Cropland | 2. Land converted to Cropland | CO2 | 2,057.84 | 265.44 | 0.000 | 0.0% | 0.0012 | 0.4% | 17% | 0.03 | 0.00 | 0.22 | 0.01 |
| #75 | 5B Cropland | | CH4 | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #76 | 5B Cropland | | N2O | 68.27 | 7.86 | 0.000 | 0.0% | 0.0000 | 0.0% | 76% | 0.00 | 0.00 | 0.03 | 0.00 |
| #77 | 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 |
| #78 | 5C Grassland | 2. Land converted to Grassland | CO2 | 516.21 | 614.90 | 0.000 | 0.0% | 0.0000 | 0.0% | 19% | 0.08 | 0.00 | 0.01 | 0.00 |
| #79 | 5C Grassland | | CH4 | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #80 | 5C Grassland | | N2O | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #81 | 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 |
| #82 | 5D Wetlands | 2. Land converted to Wetlands | CO2 | 292.33 | 167.06 | 0.000 | 0.0% | 0.0001 | 0.0% | 21% | 0.02 | 0.00 | 0.02 | 0.00 |
| #83 | 5D Wetlands | | CH4 | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #84 | 5D Wetlands | | N2O | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #85 | 5E Settlements | 1. Settlements remaining Settlements | CO2 | 475.77 | 677.60 | 0.000 | 0.0% | 0.0001 | 0.0% | 82% | 0.38 | 0.01 | 0.08 | 0.00 |
| #86 | 5E Settlements | 2. Land converted to Settlements | CO2 | 3,548.45 | 1,526.38 | 0.001 | 0.1% | 0.0015 | 0.5% | 15% | 0.15 | 0.00 | 0.21 | 0.01 |
| #87 | 5E Settlements | | CH4 | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #88 | 5E Settlements | | N2O | 0.00 | 0.00 | 0.000 | 0.0% | 0.0000 | 0.0% | 0% | 0.00 | 0.00 | 0.00 | 0.00 |
| #89 | 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 |
| #90 | 5F Other Land | 2. Land converted to Other Land | CO2 | 956.66 | 607.70 | 0.000 | 0.0% | 0.0003 | 0.1% | 30% | 0.12 | 0.00 | 0.08 | 0.00 |
| #91 | 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 |
| #92 | 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 |
| #93 | 5G Other | CO2 emissions from agricultural lime application | CO2 | 550.22 | 230.34 | 0.000 | 0.0% | 0.0002 | 0.1% | 51% | 0.08 | 0.00 | 0.12 | 0.00 |
| #94 | 6A Solid Waste Disposal on Land | | CH4 | 8,285.86 | 4,516.93 | 0.003 | 0.3% | 0.0028 | 0.9% | 29% | 0.88 | 0.02 | 0.80 | 0.03 |
| #95 | 6B Wastewater Handling | | CH4 | 2,120.57 | 1,369.21 | 0.001 | 0.1% | 0.0006 | 0.2% | 43% | 0.40 | 0.01 | 0.25 | 0.01 |
| #96 | 6B Wastewater Handling | | N2O | 1,289.65 | 1,159.00 | 0.001 | 0.1% | 0.0002 | 0.0% | 93% | 0.74 | 0.01 | 0.14 | 0.01 |
| #97 | 6C Waste Incineration | | CO2 | 12,173.71 | 14,226.64 | 0.010 | 1.0% | 0.0007 | 0.2% | 50% | 4.85 | 0.08 | 0.33 | 0.01 |
| #98 | 6C Waste Incineration | | CH4 | 13.47 | 9.81 | 0.000 | 0.0% | 0.0000 | 0.0% | 86% | 0.01 | 0.00 | 0.00 | 0.00 |
| #99 | 6C Waste Incineration | | N2O | 1,517.74 | 2,296.09 | 0.002 | 0.2% | 0.0004 | 0.1% | 103% | 1.62 | 0.03 | 0.42 | 0.02 |
| #100 | 6D Other | | CO2 | 702.83 | 559.75 | 0.000 | 0.0% | 0.0001 | 0.0% | 25% | 0.09 | 0.00 | 0.03 | 0.00 |
| #101 | 6D Other | | CH4 | 14.48 | 16.64 | 0.000 | 0.0% | 0.0000 | 0.0% | 74% | 0.01 | 0.00 | 0.00 | 0.00 |
| #102 | 6D Other | | N2O | 12.83 | 14.74 | 0.000 | 0.0% | 0.0000 | 0.0% | 86% | 0.01 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | | | |
| | TOTAL | | | 1,348,655.72 | 1,461,221.92 | 1.00 | 100.0% | 0.31 | 100.0% | | 57.65 | 1.00 | 27.20 | 1.00 |

## Table 10 Data used for the key category analysis (FY 1990)

| | A<br>IPCC Category | | B<br>Direct GHGs | C<br>Base Year Estimate [Gg CO2 eq.] | E<br>Level Assesslent | F<br>% Contribution to Level | I<br>Source/Sink Uncertinty | J<br>Level Uncertainty ( x 1000) | K<br>Contribution to Total L2 |
|---|---|---|---|---|---|---|---|---|---|
| #1 | 1A Stationary Combustion | Liquid Fuels | CO2 | 435,168.99 | 0.323 | 32.3% | 1% | 3.12 | 0.05 |
| #2 | 1A Stationary Combustion | Solid Fuels | CO2 | 308,620.23 | 0.229 | 22.9% | 1% | 3.43 | 0.05 |
| #3 | 1A Stationary Combustion | Gaseous Fuels | CO2 | 104,300.83 | 0.077 | 7.7% | 0% | 0.23 | 0.00 |
| #4 | 1A Stationary Combustion | Other Fuels | CO2 | 8,875.30 | 0.007 | 0.7% | 12% | 0.82 | 0.01 |
| #5 | 1A Stationary Combustion | | CH4 | 533.48 | 0.000 | 0.0% | 47% | 0.19 | 0.00 |
| #6 | 1A Stationary Combustion | | N2O | 2,332.05 | 0.002 | 0.2% | 33% | 0.57 | 0.01 |
| #7 | 1A Stationary Combustion | | CH4 | 50.77 | 0.000 | 0.0% | 105% | 0.04 | 0.00 |
| #8 | 1A Stationary Combustion | | N2O | 387.23 | 0.000 | 0.0% | 37% | 0.11 | 0.00 |
| #9 | 1A3 Mobile Combustion | a. Civil Aviation | CO2 | 7,162.41 | 0.005 | 0.5% | 3% | 0.13 | 0.00 |
| #10 | 1A3 Mobile Combustion | b. Road Transportation | CO2 | 189,227.88 | 0.140 | 14.0% | 2% | 3.23 | 0.05 |
| #11 | 1A3 Mobile Combustion | c. Railways | CO2 | 932.45 | 0.001 | 0.1% | 2% | 0.02 | 0.00 |
| #12 | 1A3 Mobile Combustion | d. Navigation | CO2 | 13,730.95 | 0.010 | 1.0% | 2% | 0.24 | 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 | 266.66 | 0.000 | 0.0% | 64% | 0.13 | 0.00 |
| #15 | 1A3 Mobile Combustion | c. Railways | CH4 | 1.18 | 0.000 | 0.0% | 14% | 0.00 | 0.00 |
| #16 | 1A3 Mobile Combustion | d. Navigation | CH4 | 26.33 | 0.000 | 0.0% | 200% | 0.04 | 0.00 |
| #17 | 1A3 Mobile Combustion | a. Civil Aviation | N2O | 69.75 | 0.000 | 0.0% | 10000% | 5.17 | 0.08 |
| #18 | 1A3 Mobile Combustion | b. Road Transportation | N2O | 3,901.71 | 0.003 | 0.3% | 71% | 2.05 | 0.03 |
| #19 | 1A3 Mobile Combustion | c. Railways | N2O | 121.38 | 0.000 | 0.0% | 11% | 0.01 | 0.00 |
| #20 | 1A3 Mobile Combustion | d. Navigation | N2O | 111.31 | 0.000 | 0.0% | 1000% | 0.83 | 0.01 |
| #21 | 1B Fugitive Emission | 1a i. Coal Mining and Handling (under | CH4 | 2,785.23 | 0.002 | 0.2% | 107% | 2.21 | 0.03 |
| #22 | 1B Fugitive Emission | 1a ii. Coal Mining and Handling | 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% | 21% | 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% | 23% | 0.03 | 0.00 |
| #28 | 1B Fugitive Emission | 2c. Venting & Flaring | CO2 | 36.23 | 0.000 | 0.0% | 18% | 0.00 | 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 | 37,966.28 | 0.028 | 2.8% | 10% | 2.94 | 0.04 |
| #32 | 2A Mineral Product | 2. Lime Production | CO2 | 7,321.64 | 0.005 | 0.5% | 16% | 0.86 | 0.01 |
| #33 | 2A Mineral Product | 3. Limestone and Dolomite Use | CO2 | 11,527.41 | 0.009 | 0.9% | 17% | 1.42 | 0.02 |
| #34 | 2A Mineral Product | 4. Soda Ash Production and Use | CO2 | 583.63 | 0.000 | 0.0% | 16% | 0.07 | 0.00 |
| #35 | 2B Chemical Industry | 1. Ammonia Production | CO2 | 3,384.68 | 0.003 | 0.3% | 23% | 0.58 | 0.01 |
| #36 | 2B Chemical Industry | other products except Anmonia | CO2 | 1,129.29 | 0.001 | 0.1% | 77% | 0.65 | 0.01 |
| #37 | 2B Chemical Industry | 2. Nitric Acid | N2O | 765.70 | 0.001 | 0.1% | 46% | 0.26 | 0.00 |
| #38 | 2B Chemical Industry | 3. Adipic Acid | N2O | 7,501.25 | 0.006 | 0.6% | 9% | 0.51 | 0.01 |
| #39 | 2B Chemical Industry | 4. Carbide Production | CH4 | 0.42 | 0.000 | 0.0% | 100% | 0.00 | 0.00 |
| #40 | 2B Chemical Industry | 5. Carbon Black, Ethylene, Ethylene Dichloride, Styrene, Methanol, Coke | CH4 | 337.80 | 0.000 | 0.0% | 89% | 0.22 | 0.00 |
| #41 | 2C Metal Production | 1 Iron and Steel Production | CO2 | 356.09 | 0.000 | 0.0% | 5% | 0.01 | 0.00 |
| #42 | 2C Metal Production | 1 Iron and Steel Production | CH4 | 15.47 | 0.000 | 0.0% | 163% | 0.02 | 0.00 |
| #43 | 2C Metal Production | 2. Ferroalloys Production | CH4 | 3.89 | 0.000 | 0.0% | 163% | 0.00 | 0.00 |
| #44 | 2C Metal Production | 3. Aluminium Production | PFCs | 69.74 | 0.000 | 0.0% | 33% | 0.02 | 0.00 |
| #45 | 2C Metal Production | 4. SF6 Used in Aluminium and Magnesium oundries | SF6 | 119.50 | 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 | 16,965.00 | 0.013 | 1.3% | 5% | 0.68 | 0.01 |
| #47 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | HFCs | 480.12 | 0.000 | 0.0% | 100% | 0.36 | 0.01 |
| #48 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | PFCs | 762.85 | 0.001 | 0.1% | 100% | 0.57 | 0.01 |
| #49 | 2E Production of Halocarbons and SF6 | 2. Fugitive Emissions | SF6 | 4,708.30 | 0.003 | 0.3% | 100% | 3.51 | 0.05 |
| #50 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 1. Refrigeration and Air Conditioning Equipment | HFCs | 840.40 | 0.001 | 0.1% | 42% | 0.26 | 0.00 |
| #51 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 2. Foam Blowing | HFCs | 451.76 | 0.000 | 0.0% | 51% | 0.17 | 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 | 1,365.00 | 0.001 | 0.1% | 31% | 0.31 | 0.00 |
| #54 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 5. Solvents | PFCs | 10,382.05 | 0.008 | 0.8% | 40% | 3.08 | 0.04 |
| #55 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | HFCs | 158.30 | 0.000 | 0.0% | 64% | 0.08 | 0.00 |
| #56 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | PFCs | 3,148.83 | 0.002 | 0.2% | 64% | 1.49 | 0.02 |
| #57 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 7. Semiconductor Manufacture | SF6 | 1,128.98 | 0.001 | 0.1% | 64% | 0.54 | 0.01 |
| #58 | 2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2) | 8. Electrical Equipment | SF6 | 11,004.99 | 0.008 | 0.8% | 40% | 3.28 | 0.05 |
| #59 | 3 Solvent & Other Product Use | Using Laughing Gas in Hospital | N2O | 287.07 | 0.000 | 0.0% | 5% | 0.01 | 0.00 |
| #60 | 4A Enteric Fermentation | | CH4 | 7,674.46 | 0.006 | 0.6% | 12% | 0.67 | 0.01 |
| #61 | 4B Manure Management | | CH4 | 3,104.72 | 0.002 | 0.2% | 64% | 1.48 | 0.02 |
| #62 | 4B Manure Management | | N2O | 5,661.40 | 0.004 | 0.4% | 48% | 2.02 | 0.03 |
| #63 | 4C Rice Cultivation | | CH4 | 7,002.78 | 0.005 | 0.5% | 23% | 1.18 | 0.02 |
| #64 | 4D Agricultural Soils | 1. Direct Soil Emissions | N2O | 4,249.46 | 0.003 | 0.3% | 90% | 2.84 | 0.04 |
| #65 | 4D Agricultural Soils | 2. Pasture, Range and Paddock Manure | N2O | 11.91 | 0.000 | 0.0% | 133% | 0.01 | 0.00 |
| #66 | 4D Agricultural Soils | 3. Indirect Emissions | N2O | 3,669.26 | 0.003 | 0.3% | 64% | 1.73 | 0.03 |
| #67 | 4F Field Burning of Agricultural | | CH4 | 129.77 | 0.000 | 0.0% | 142% | 0.14 | 0.00 |
| #68 | 4F Field Burning of Agricultural | | N2O | 103.92 | 0.000 | 0.0% | 186% | 0.14 | 0.00 |
| #69 | 5A Forest Land | 1. Forest Land remaining Forest Land | CO2 | 75,127.14 | 0.056 | 5.6% | 6% | 3.20 | 0.05 |
| #70 | 5A Forest Land | 2. Land converted to Forest Land | CO2 | 5,650.70 | 0.004 | 0.4% | 6% | 0.26 | 0.00 |
| #71 | 5A Forest Land | | CH4 | 8.31 | 0.000 | 0.0% | 53% | 0.00 | 0.00 |
| #72 | 5A Forest Land | | N2O | 0.84 | 0.000 | 0.0% | 89% | 0.00 | 0.00 |
| #73 | 5B Cropland | 1. Cropland remaining Cropland | CO2 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #74 | 5B Cropland | 2. Land converted to Cropland | CO2 | 2,057.84 | 0.002 | 0.2% | 17% | 0.27 | 0.00 |
| #75 | 5B Cropland | | CH4 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #76 | 5B Cropland | | N2O | 68.27 | 0.000 | 0.0% | 76% | 0.04 | 0.00 |
| #77 | 5C Grassland | 1. Grassland remaining Grassland | CO2 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #78 | 5C Grassland | 2. Land converted to Grassland | CO2 | 516.21 | 0.000 | 0.0% | 19% | 0.07 | 0.00 |
| #79 | 5C Grassland | | CH4 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #80 | 5C Grassland | | N2O | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #81 | 5D Wetlands | 1. Wetlands remaining Wetlands | CO2 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #82 | 5D Wetlands | 2. Land converted to Wetlands | CO2 | 292.33 | 0.000 | 0.0% | 21% | 0.05 | 0.00 |
| #83 | 5D Wetlands | | CH4 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #84 | 5D Wetlands | | N2O | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #85 | 5E Settlements | 1. Settlements remaining Settlements | CO2 | 475.77 | 0.000 | 0.0% | 82% | 0.29 | 0.00 |
| #86 | 5E Settlements | 2. Land converted to Settlements | CO2 | 3,548.45 | 0.003 | 0.3% | 15% | 0.38 | 0.01 |
| #87 | 5E Settlements | | CH4 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #88 | 5E Settlements | | N2O | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #89 | 5F Other Land | 1. Other Land remaining Other Land | CO2 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #90 | 5F Other Land | 2. Land converted to Other Land | CO2 | 956.66 | 0.001 | 0.1% | 30% | 0.21 | 0.00 |
| #91 | 5F Other Land | | CH4 | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #92 | 5F Other Land | | N2O | 0.00 | 0.000 | 0.0% | 0% | 0.00 | 0.00 |
| #93 | 5G Other | CO2 emissions from agricultural lime application | CO2 | 550.22 | 0.000 | 0.0% | 51% | 0.21 | 0.00 |
| #94 | 6A Solid Waste Disposal on Land | | CH4 | 8,285.86 | 0.006 | 0.6% | 29% | 1.75 | 0.03 |
| #95 | 6B Wastewater Handling | | CH4 | 2,120.57 | 0.002 | 0.2% | 43% | 0.67 | 0.01 |
| #96 | 6B Wastewater Handling | | N2O | 1,289.65 | 0.001 | 0.1% | 93% | 0.89 | 0.01 |
| #97 | 6C Waste Incineration | | CO2 | 12,173.71 | 0.009 | 0.9% | 50% | 4.49 | 0.07 |
| #98 | 6C Waste Incineration | | CH4 | 13.47 | 0.000 | 0.0% | 86% | 0.01 | 0.00 |
| #99 | 6C Waste Incineration | | N2O | 1,517.74 | 0.001 | 0.1% | 103% | 1.16 | 0.02 |
| #100 | 6D Other | | CO2 | 702.83 | 0.001 | 0.1% | 25% | 0.13 | 0.00 |
| #101 | 6D Other | | CH4 | 14.48 | 0.000 | 0.0% | 74% | 0.01 | 0.00 |
| #102 | 6D Other | | N2O | 12.83 | 0.000 | 0.0% | 86% | 0.01 | 0.00 |
| | | | | | | | | | |
| | TOTAL | | | 1,348,655.72 | 1.00 | 100.0% | | 68.83 | 1.00 |

### 1.2.4. 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, and unexpectedly high or low estimates are identified.

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

## 2.1. Emission Factors for Coke, Coke Oven Gas, and Blast Furnace Gas, etc.

Emission factor for BFG [$172][1] was established with annually calculated value in order to keep carbon balance in blast furnace and L.D. converter during iron and steel production process. The amount of carbon excluded carbon contained in LDG [$173] from carbon (contained in 'Coke' [$161] and 'PCI coal' [$112]) injected to blast furnace indicated under 'Steel process gas' [#2550] is considered to be carbon contained in BFG. Emission factor for BFG was established as carbon described above divided by calorific values of BFG generated. The equation for emission factor and the overview of carbon flow for iron & steel and calculation process are shown below.

Calculation to establish emission factor for BFG is conducted every year.

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

| | |
|---|---|
| EF | : Carbon content of the fuel [ tC/TJ ] |
| A | : Fuel consumption [TJ] |
| BFG | : Blast Furnace Gas ［$172］ |
| coal | : PCI coal ［$112］ |
| coke | : coke ［$161］ |
| LDG | : L.D converter gas ［$172］ |

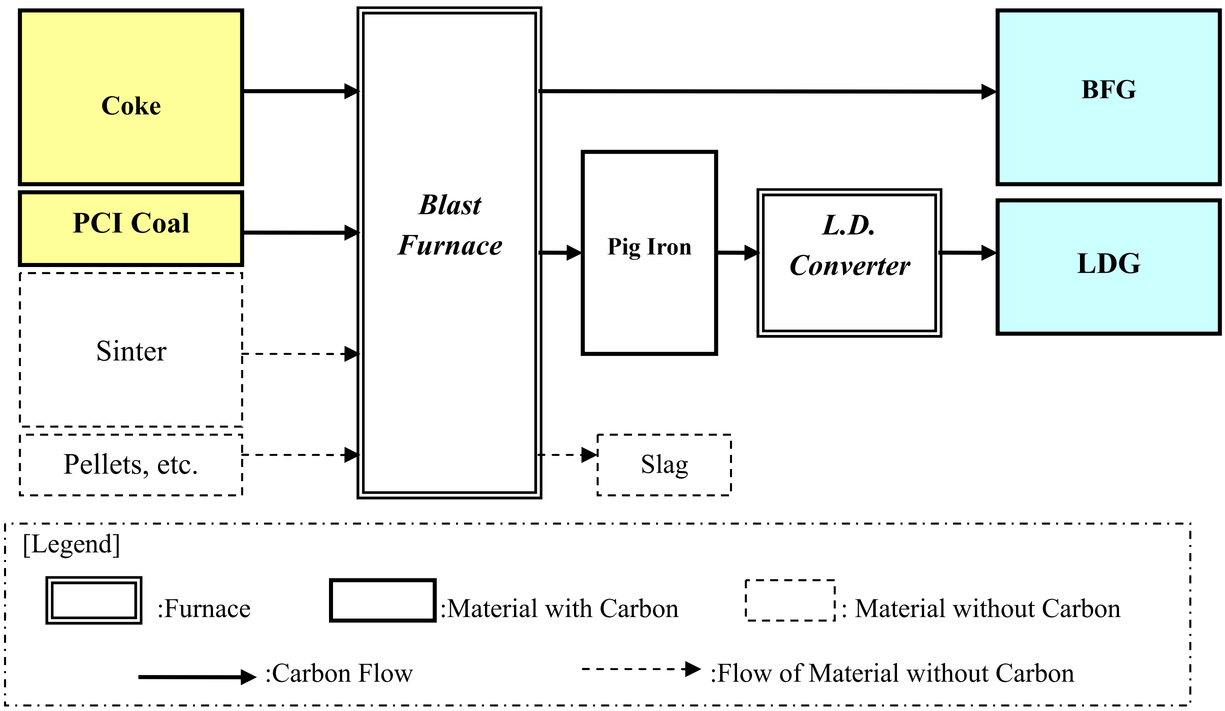


Figure 1 Overview of carbon flow for iron & steel

[1] Codes in brackets indicate column and row number indicated in the *Yearbook of the Current Survey of Energy*

Table 1 Calculation of Emission Factors for BFG

| #2550 Steel Process Gas | | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | Note |
|---|---|---|---|---|---|---|---|---|
| Input | | | | | | | | |
| $112 PCI Coal | Gg-C | 1,574 | 2,593 | 3,518 | 3,111 | 3,226 | 3,515 | A |
| $161 Coke | Gg-C | 12,830 | 11,432 | 12,021 | 11,382 | 11,627 | 11,782 | B |
| Input Total | Gg-C | 14,404 | 14,024 | 15,539 | 14,492 | 14,853 | 15,297 | C: A + B |
| Output | | | | | | | | |
| $173 LDG | Gg-C | 2,541 | 2,359 | 2,726 | 2,804 | 2,999 | 3,038 | D |
| Difference | Gg-C | 11,863 | 11,665 | 12,813 | 11,688 | 11,854 | 12,259 | E: C - D |
| Output | | | | | | | | |
| $172 BFG | TJ | 434,801 | 433,504 | 481,768 | 441,357 | 449,335 | 465,388 | F |
| EF $172 BFG | t-C/TJ | 27.28 | 26.91 | 26.60 | 26.48 | 26.38 | 26.34 | E / F |

## 2.2. Emission Factor for Town Gas

'Town gas' [$450] consists of 'Town gas' [$460] provided by town gas supplier and 'Small scale town gas' [$470] provided by small scale town gas supplier.

In the case of small scale town gas supplier:

Because most part of small scale town gas is LPG  the same emission factor for LPGs was adopted for small scale town gas

In the case of town gas supplier:

Emission factors for town gas were established based on carbon balance in 'Town gas production' [#2400]. To calculate town gas emission factors, the total carbon in fossil fuel inputs used as raw materials (COG [$171], Kerosene [$330], Refinery gas [$380], LPG [$390], LNG [$410] and Indigenous natural gas [$420]) was divided by the total calorific value of the town gas production.

Calculation to establish emission factor for town gas is conducted every year.

$$EF_{TG} = \sum \left( A_i * EF_i \right) / P_{TG}$$

EF : Carbon content of the fuel [ tC/TJ ]

A : Fuel consumption [TJ]

TG : Town gas［$460］

i : Feedstocks (COG [$171], Kerosine [$330], Refinery gas [$380], LPG [$390], LNG [$410], Indigenous natural gas［$420］

Consumption.

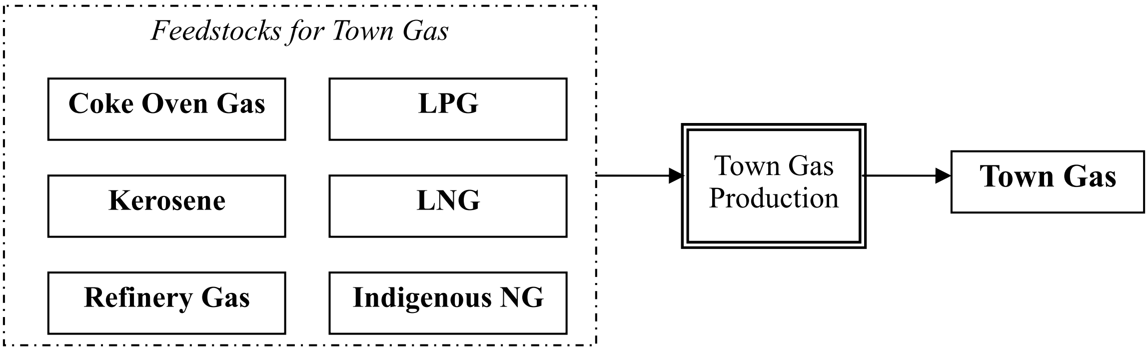


Figure 2 Manufacturing Flow for Town Gas

Table 2 Calculation of Emission Factors for Town Gas

| #2400 Town Gas Production | | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 | Note |
|---|---|---|---|---|---|---|---|---|
| Input | | | | | | | | |
| $171 COG | Gg-C | 211 | 134 | 105 | 22 | 0 | 0 | a1 |
| $330 Kerosene | Gg-C | 200 | 275 | 69 | 6 | 0 | 0 | a2 |
| $380 Refinery Gas | Gg-C | 186 | 199 | 186 | 145 | 101 | 95 | a3 |
| $390 LPG | Gg-C | 1,931 | 2,104 | 1,791 | 1,082 | 741 | 736 | a4 |
| $410 LNG | Gg-C | 6,253 | 9,107 | 11,642 | 16,563 | 18,594 | 19,774 | a5 |
| $420 Indigenous NG | Gg-C | 551 | 661 | 848 | 1,190 | 1,534 | 1,748 | a6 |
| Input Total | Gg-C | 9,331 | 12,480 | 14,641 | 19,007 | 20,969 | 22,352 | A: Σa |
| Output | | | | | | | | |
| $460 Town Gas | TJ | 664,661 | 892,307 | 1,061,122 | 1,391,962 | 1,534,754 | 1,644,759 | B |
| EF $460 Town Gas | t-C/TJ | 14.04 | 13.99 | 13.80 | 13.65 | 13.66 | 13.59 | A/B |

## 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 3 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 can not 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 Figure 3, 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 3 Surveyed industries and products in *Yearbook of the Current Survey of Energy Consumption*

<table>
<tr><th rowspan="2">Surveyed industry</th><th colspan="2">from 1990 to 1997</th><th colspan="2">after 1997</th></tr>
<tr><th>Products</th><th>Scope of survey</th><th>Products</th><th>Scope of survey</th></tr>
<tr><td>Pulp and paper industry</td><td>* Pulp<br>* Paper<br>* Sheet paper</td><td>All<br>Establishments with 50 or more employees<br>Establishments with 50 or more employees</td><td>* Pulp<br>* Paper<br>* Sheet paper</td><td>All<br>Establishments with 50 or more employees<br>Establishments with 50 or more employees</td></tr>
<tr><td>Chemical industry (except chemical fiber industry)</td><td>* Petrochemical products<br>* Ammonia and amonia-derived products<br>* Soda industries chemicals<br>* High pressure gas ($O_2$, $N_2$, Ar)<br>* Inorganic chemicals and colorant (titanic oxide, active char, chinese white, iron oxide)<br>* Oil and fat products and surfactant</td><td>All<br>All<br>All<br>All (except high pressure gas products by air fraction method(gas container))<br>All<br>Establishments with 30 or more employees</td><td>* Petrochemical products<br>* Ammonia and amonia-derived products<br>* Soda industries chemicals</td><td>All</td></tr>
<tr><td>Chemical fiber industry</td><td>* Chemical fibers</td><td>Establishments with 30 or more employees</td><td>* Chemical fibers</td><td>Establishments with 30 or more employees</td></tr>
<tr><td>Petroleum products industry</td><td>* Petroleum products (except grease)</td><td>All</td><td>* Petroleum products (except grease)</td><td>All</td></tr>
<tr><td>Ceramics, clay and stone products industry (except glass product industry, with the exception of sheet glass industry)</td><td>* Cement<br>* Sheet glass<br>* Lime<br>* Fire brick<br>* Carbon products</td><td>All<br>All<br>Establishments with 30 or more employees<br>Establishments with 30 or more employees<br>All</td><td>* Cement<br>* Sheet glass<br>* Lime</td><td>All<br>All<br>Establishments with 30 or more employees</td></tr>
<tr><td>Glass product industry (except sheet glass industry)</td><td>* Glass products</td><td>Establishments with 10 or more employees</td><td>* Glass products</td><td>Establishments with 100 or more employees</td></tr>
<tr><td>Iron and steel industry</td><td>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.</td><td>All</td><td>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.</td><td>All</td></tr>
<tr><td>Non-ferrous metal industry</td><td>* Non-ferrous metals</td><td>All</td><td>* Copper<br>* Lead<br>* Zinc<br>* Aluminum<br>* Alminum secondary ground metal</td><td>All<br>All<br>All<br>All<br>Establishments with 30 or more employees</td></tr>
<tr><td>Machinery industry</td><td>* Machinery and appliances<br>* cast and forged products</td><td>Establishments with 500 or more employees<br>Establishments with 100 or more employees</td><td>* 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)</td><td>Establishments with 500 or more employees which are designated by the Minister of International Trade and Industry</td></tr>
<tr><td>Dyeing</td><td>* Dyeing wool<br>* Dyeing fablic</td><td>Establishments with 20 or more employees</td><td colspan="2">demise</td></tr>
<tr><td>Rubber product</td><td>* Tires and tube</td><td>Establishments with 30 or more employees</td><td colspan="2">demise</td></tr>
<tr><td>Non-ferrous metal product</td><td>* Copper and brass<br>* Flat-rolled aluminum<br>* Electric cable<br>* Alminum secondary bare metal</td><td>All<br>All<br>Establishments with 30 or more employees<br>Establishments with 30 or more employees</td><td colspan="2">demise</td></tr>
</table>

## 2.4. $CO_2$ emissions from Coal Products Section

Coal Products [#2500] is the section that expresses the energy conversion processes that produce coal products from coal. In the section, there is a difference between the amount of input carbon and output carbon on coke production process. The difference is reported as $CO_2$ emissions of coal products section because that carbon is assumed as the amount of coke oxidized by exposing to the atmosphere while being transported in the quenching car from the coke furnace to CDQ (Coke Dry Quenching) among others, though it is necessary to examine this issue further.
Activity data is estimated by dividing $CO_2$ emissions by carbon emission factor of coke.

## 2.5. 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 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 fuel consumption by international flights and international marine; 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. The changes in the stock data were caused by the difference in the classification of fuel oil A as well as by circumstances specific to individual items.
Heavy Oil A has a flash point of more than 60 ℃, kinematic viscosity of 20 m $m^2$/s below, carbon residue content of 4% below and sulfur content of 2.0 % below. Heavy Oil B has a flash point of more than 60 ℃, kinematic viscosity of 50 m $m^2$/s below, carbon residue content of 8% below and sulfur content of 3.0 % below. Heavy Oil B is rarely used in Japan, for this reason, heavy oil B is treated as heavy oil B/C in a statistics. Heavy Oil C has a flash point of more than 70 ℃, kinematic viscosity of less than 1000 m $m^2$/s and sulfur content of less than 3.5%.
Further explanations are provided below for each of the discrepancies noted by the ERT.

The IEA statistical data used in the Reference tables below were extracted from the Energy Statistics of OECD Countries 2004–2005 (CD-ROM version), 2007 Edition, OECD/IEA.

### *a） Differences in exports of jet kerosene and residual fuel oil*

<ERT findings>
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 final consumption of jet kerosene by international aviation as an aggregate of the bonded exports and imports. (See Chapter 3, page 3-34, for bonded exports and imports.)

<Reference: Exports of jet kerosene in 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Exports: 6,688.96× $10^3$ kL<br><br><Breakdown><br>Exports excluding bonded exports: 851.28× $10^3$ kL<br>Bonded exports: 5,837.68× $10^3$ kL | Exports: 667× $10^3$ t<br>[851.28× $10^3$ kL (exports excluding bonded exports) × 0.7834 (specific gravity) = 667× $10^3$ t]<br><br><Remarks><br>International aviation: 6,825× $10^3$ t<br>[5,837.68× $10^3$ kL (bonded exports) + 2,874.92× $10^3$ kL (bonded imports)* = 8,712.60× $10^3$ kL;<br>8,712.60× $10^3$ kL × 0.7834 (specific gravity) = 6,825× $10^3$ t]<br><br>* The bonded imports in the 2005 statistics were revised to 2,821.84× $10^3$ kL in the 2006 statistics. |

<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, page 3-34, 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 Heavy 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 gas oil in Japan, is grouped together with gas oil in Europe and the United States, the fuel oil A data have been included in the gas oil data in Japan's report to the IEA.

<Reference: Exports of residual fuel oil in 2005>

| CRF Table 1.A(b) | IEA Statistics/Heavy Fuel oil |
|---|---|
| Exports: 10,035.13× $10^3$ kL<br>[167.98× $10^3$ kL (fuel oil A) + 9,867.15× $10^3$ kL (fuel oils B and C) = 10,035.13× $10^3$ kL] | Exports: 3,018× $10^3$ t<br>[3,352.98× $10^3$ kL (exports of fuel oils B and C excluding bonded exports) × 0.9 (specific gravity) = 3,018× $10^3$ t] |

| <Breakdown> | <Remarks> |
|---|---|
| Exports of fuel oil A: 167.98× $10^3$ kL<br>Exports excluding bonded exports: 0<br>Bonded exports: 167.98× $10^3$ kL<br><br>Exports of fuel oils B and C: 9,867.15× $10^3$ kL<br>Exports excluding bonded exports: 3,352.98× $10^3$ kL<br>Bonded exports: 6,514.17× $10^3$ kL | International marine bunkers: 5,889× $10^3$ t<br>[6,514.17× $10^3$ kL (bonded exports of fuel oils B and C) + 29.48× $10^3$ kL (bonded imports of fuel oils B and C) = 6,543.65× $10^3$ kL;<br>6,543.65× $10^3$ kL × 0.9 (specific gravity) = 5,889× $10^3$ t] |

### *b）Differences in imports of jet kerosene and gas/diesel oil*

<ERT findings>

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 do not include bonded imports while the IEA statistics do. (See Chapter 3, page 3-34, for bonded exports and imports.)

<Reference: Jet kerosene imports in 1990>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Imports: NO<br><br><Jet kerosene imports><br>Imports excluding bonded imports: 0<br>Bonded imports: 4,446.44× $10^3$ kL | Imports: 3,483× $10^3$ t<br>[4,446.44× $10^3$ kL (imports including bonded imports) × 0.7834 (specific gravity) = 3,483× $10^3$ 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 (excluding bonded imports) do not include fuel oil A while the figures for imports of gas/diesel oil in the IEA statistics are the aggregate of imports of gas oil and fuel oil A, both of which included the bonded imports. (See a) above.)

<Reference: Imports of gas/diesel oil in 1990>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Imports: 4,953.85× $10^3$ kL<br><br><Imports of gas oil><br>Imports excluding bonded imports:<br>4,953.85× $10^3$ kL<br>Bonded imports: 32.90× $10^3$ kL | Imports: 5,450× $10^3$ t<br>[4,986.75× $10^3$ kL (imports of gas oil including bonded imports) + 1,663.52× $10^3$ kL (imports of fuel oil A including bonded imports) = 6,650.27× $10^3$ kL;<br>6,650.27× $10^3$ kL × 0.843 (specific gravity) = 5,606× $10^3$ t] |
| | <Remarks><br>The imports calculated by the formula in the brackets above differ from the imports reported in the IEA statistics due to an omission of bonded imports from the imports of fuel oil A. The correction (to 5,606 kt) was reported to the IEA in April 2008. |

### *c） Differences in imports of coking coal*

<ERT findings>

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 figures for imports of coking coal reported in the CRF tables are the same as the figures reported in the IEA statistics.

<Reference: Imports of coking coal in 1999>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Imports: 54,880.04× $10^3$ t | Imports: 54,880× $10^3$ t |

### *d） Differences in stock changes in liquid and gaseous fuels*

<ERT findings>

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.

<Reference: Changes of crude oil stock in 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: - 673× $10^3$ kL | Stock changes: 276× $10^3$ 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 changes in NGL stock were estimated by a method developed for the calculation of estimates from the production, imports, and shipment data, etc, for NGL in order to minimize error in the energy and carbon balances with respect to oil refining for the years 1990 to 2003.

<Reference: Changes in NGL stock in 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 3,430.63× $10^3$ kL | Stock changes: 0 |

<Explanation 3: Changes in gasoline stock>

The figures for changes in gasoline stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in gasoline stock in 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 76.92× $10^3$ kL | Stock changes in motor gasoline: 57× $10^3$ t<br>[76.92× $10^3$ kL × 0.737 (specific gravity) =<br>= 57× $10^3$ t]<br>Stock changes in white spirit: 0 |

<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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 97.17× $10^3$ kL | Stock changes: 76× $10^3$ t<br>[97.17× $10^3$ kL ( 0.7834 (specific gravity) = 76× $10^3$ 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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 537.28× $10^3$ kL | Stock changes: 437× $10^3$ t<br>[537.28× $10^3$ kL × 0.814 (specific gravity) = 437× $10^3$ t] |

<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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 321.21× $10^3$ kL | Stock changes: 402× $10^3$ t<br>[321.21× $10^3$ kL × 0.843 (specific gravity) = 270.78× $10^3$ t (stock changes in gas oil);<br>155.30× $10^3$ kL × 0.843 (specific gravity) = 130.92× $10^3$ t (stock changes in fuel oil A);<br>270.78 + 130.92 = 402× $10^3$ 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 Heavy 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 2005>

| CRF Table 1.A(b) | IEA Statistics/Heavy Fuel oil |
|---|---|
| Stock changes: 74.59× $10^3$ kL<br><br><Breakdown><br>Stock changes in fuel oil A: 155.30× $10^3$ kL<br>Stock changes in fuel oil C: - 80.71× $10^3$ kL | Stock changes: - 72× $10^3$ t<br>[- 80.71× $10^3$ kL (stock changes in fuel oil C) × 0.900 (specific gravity) = - 72.64× $10^3$ t] |

<Explanation 8: Changes in LPG stock>

The figures for changes in LPG stock reported in the CRF tables are the same as the figures in the IEA statistics.

<Reference: Changes in LPG stock in 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 310.88× $10^3$ t | Stock changes: 310× $10^3$ 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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: - 53.55× $10^3$ kL | Stock changes: - 39× $10^3$ t<br>[- 53.55× $10^3$ kL × 0.737 (specific gravity) = -39× $10^3$ 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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: -20.03× $10^3$ t<br><Breakdown><br>Asphalt: -19.37× $10^3$ t<br>Other heavy oils and paraffin products:<br>-0.66× $10^3$ t | Stock changes in bitumen: -19× $10^3$ t<br><Remarks><br>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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: -7.94× $10^3$ kL | Stock changes: -7× $10^3$ t<br>[-7.94× $10^3$ kL × 0.891 (specific gravity) = -7× $10^3$ 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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 5× $10^3$ t | Stock changes: 5× $10^3$ t |

<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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Stock changes: 502.16× $10^3$ kL<br><br><Breakdown><br>Slack gasoline: -35.29× $10^3$ kL<br>Slack kerosene: 78.26× $10^3$ kL<br>Slack diesel oil or gas oil: 359.83× $10^3$ kL<br>Slack fuel oil: 99.35× $10^3$ kL<br>(Slack fuel oil is the aggregate of 139.32× $10^3$ kL for slack fuel oil and -39.97× $10^3$ kL for slack luburicant) | Stock changes: 416× $10^3$ t<br><br><Breakdown><br>Slack gasoline: -42.74× $10^3$ kL<br>Slack kerosene: 78.26× $10^3$ kL<br>Slack diesel oil or gas oil: 359.83× $10^3$ kL<br>Slack fuel oil: 139.32× $10^3$ kL<br>Slack lubricant: -39.97× $10^3$ kL<br>Slack wax: -4.53× $10^3$ kL<br>Slack coke: -5.04× $10^3$ kL<br><br>Each of the above figures is multiplied by its specific gravity for conversion to weight for reporting purposes. |
| <Remarks><br>The differences between monthly statistics and yearly statistics caused the difference in the changes of stock of slack gasoline between the CRF tables and the IEA 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 reported 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, data were estimated for the imported LNG due to the lack of stock statistics.

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 2005>

| CRF Table 1.A(b) | IEA Statistics |
|---|---|
| Changes in LNG stock: -1,933.17× $10^3$ t<br>Changes in domestic natural gas stock: 3.23× $10^6 m^3$ | Stock changes: -4,846 TJ-gross<br><br><Remarks><br>The figures for LNG and natural gas were combined under Natural Gas as the IEA statistics do not separate them. |

## 2.6. General Energy Statistics

### 2.6.1. *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*, Japan's official energy statistics, provides a comprehensive overview of the supply and demand, conversion, and consumption data by sectors and by various forms of energy sources such as coal, oil, and others. The supply/conversion and consumption data in *General Energy Statistics* use official statistics and are structured with the minimum of estimation and adjustment. It also identifies the sector in which the energy sources were consumed, and in what forms, to give an overview of Japan's energy supply and demand.

The complete Energy Balance Tables for the years since 1990 are available on the following internet site:
**http://www.enecho.meti.go.jp/info/statistics/jukyu/result-2.htm**

*General Energy Statistics* provides a comprehensive overview of domestic energy supply and demand, with energy sources and sectors arranged in a matrix. Specifically, 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. *General Energy Statistics* supply and demand sectors (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. (Refer to the following General Energy Statistics simplified table.)

In calculating the energy supply and demand amounts for *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. Values for supply, conversion, and consumption in original units as determined from official statistical sources are multiplied by gross calorific value per original unit to obtain energy supply and demand amounts.
*General Energy Statistics* calculation proceeds in the following order:
(1) Set calorific values and carbon emission factors.
(2) Build energy supply and demand modules.
(3) Prepare original unit tables (integrate modules and prepare main table and summary table) (units in t, kL, $m^3$, etc).
(4) Prepare energy unit tables (Units are J).
(5) Prepare energy-derived carbon tables (given are carbon content).

*General Energy Statistics* is adopting actual calorific values based on calculation 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 document are adopted.

### 2.6.2. *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 4 and Table .

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 (Figure 3). 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.

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 '1A2 Manufacturing Industries and Construction'.

Table 4 Correspondence between sectors of General Energy Statistics (Miner Sector) and of the CRF

| CRF | | | General Energy Statistics |
|---|---|---|---|
| 1A1 | | Energy Industries | |
| | 1A1a | Public Electricity and Heat Production | #2110 Power Genertion, General Electric Utilities |
| | | | #2911 Own use, General Electric Utilities |
| | | | #2150 Power Genertion, Independent Power Producing |
| | | | #2912 Own use, Independent Power Producing |
| | | | #2350 District Heat Supply |
| | | | #2913 Own use, District Heat Supply |
| | 1A1b | Petroleum Refining | #2916 Own use, Oil Refinary |
| | 1A1c | Manufacture of Solid Fuels and Other Energy Industries | #2914 Own use, Town Gas |
| | | | #2915 Own use, Steel Coke |
| | | | #2917 Own use, Other Conversion |
| 1A2 | | Manufacturing Industries and | |
| | 1A2a | Iron and Steel | #2217 Auto: Iron & Steel |
| | | | #2307 Steam Generation: Iron & Steel |
| | | | #6580 Final Energy Consumption, Iron & Steel |
| | | | #9680 Non-Energy, Iron & Steel |
| | 1A2b | Non-Ferrous Metals | #2218 Auto: Non-Ferrous Metal |
| | | | #2308 Steam Generation: Non-Ferrous Metal |
| | | | #6590 Final Energy Consumption, Non-Ferrous Metal |
| | | | #9690 Non-Energy, Non-Ferrous Metal |
| | 1A2c | Chemicals | #2212 Auto: Chemical Textiles |
| | | | #2302 Steam Generation: Chemical Textiles |
| | | | #6530 Final Energy Consumption, Chemical Textiles |
| | | | #9630 Non-Energy, Chemical Textiles |
| | | | #2214 Auto: Chemical |
| | | | #2304 Steam Generation: Chemical |
| | | | #6550 Final Energy Consumption, Chemical |
| | | | #9650 Non-Energy, Chemical |
| | 1A2d | Pulp, Paper and Print | #2211 Auto: Pulp & Paper |
| | | | #2301 Steam Generation: Pulp & Paper |
| | | | #6520 Final Energy Consumption, Pulp & Paper |
| | | | #9620 Non-Energy, Pulp & Paper |
| | 1A2e | Food Processing, Beverages and Tobacco | #6510 Final Energy Consumption, Food |
| | | | #9610 Non-Energy, Non-Manufacturing Industry (Food) |
| | 1A2f | Other | |
| | | Mining | #6120 Final Energy Consumption, Mining |
| | | | #9610 Non-Energy, Non-Manufacturing Industry (Mining) |
| | | Construction | #6150 Final Energy Consumption, Construction |
| | | | #9610 Non-Energy, Non-Manufacturing Industry (Construction) |
| | | Oil Products | #2213 Auto: Oil products |
| | | | #2303 Steam Generation: Oil products |
| | | | #6540 Final Energy Consumption, Oil products |
| | | | #9640 Non-Energy, Oil products |
| | | Glass Wares | #2215 Auto: Glass Wares |
| | | | #2305 Steam Generation: Glass Wares |
| | | | #6560 Final Energy Consumption, Glass Wares |
| | | | #9660 Non-Energy, Glass Wares |
| | | Cement&Ceramics | #2216 Auto: Cement & Ceramics |
| | | | #2306 Steam Generation: Cement & Ceramics |
| | | | #6570 Final Energy Consumption, Cement & Ceramics |
| | | | #9670 Non-Energy, Cement & Ceramics |
| | | Machinery | #2219 Auto: Machinery & Others |
| | | | #2309 Steam Generation: Machinery & Others |
| | | | #6600 Final Energy Consumption, Machinery |
| | | | #9700 Non-Energy, Machinery |
| | | Duplication Adjustment | #2220 Auto: Duplication Adjustment |
| | | | #2310 Steam Generation: Duplication Adjustment |
| | | | #6700 Final Energy Consumption, Duplication Adjustment |
| | | | #9710 Non-Energy, Duplication Adjustment |
| | | Other Industries & SMEs | #2250 Auto: Others |
| | | | #6900 Final Energy Consumption, Other Industries & SMEs |
| | | | #9720 Non-Energy, Other Industries & SMEs |

Table 4 Correspondence between sectors of General Energy Statistics(Miner Sector) and of the CRF (cont.)

| CRF | | | General Energy Statistics |
|---|---|---|---|
| 1A3 | | Transport | |
| | 1A3a | Civil Aviation | #8140 Final Energy Consumption, Passenger Air |
| | | | #8540 Final Energy Consumption, Freight Air |
| | | | #9850 Non-Energy, Transportation (Air) |
| | 1A3b | Road Transportation | #8110 Final Energy Consumption, Passenger Car |
| | | | #8510 Final Energy Consumption, Freight Freight, Truck & Lorry |
| | | | #8115 Final Energy Consumption, Passenger Bus |
| | | | #8190 Final Energy Consumption, Passenger, Transportation fraction estimation |
| | | | #8590 Final Energy Consumption, Freight, Transportation fraction estimation error. |
| | | | #9850 Non-Energy, Transportation (Car, Truck & Lorry, Bus) |
| | 1A3c | Railways | #8120 Final Energy Consumption, Passenger Rail |
| | | | #8520 Final Energy Consumption, Freight Rail |
| | | | #9850 Non-Energy, Transportation (Rail) |
| | 1A3d | Navigation | #8130 Final Energy Consumption, Passenger Ship |
| | | | #8530 Final Energy Consumption, Freight Ship |
| | | | #9850 Non-Energy, Transportation |
| | 1A3e | Other Transportation | - - |
| 1A4 | | Other Sectors | |
| | 1A4a | Commercial/Institutional | #7500 Final Energy Consumption, Commercial & Others |
| | | | #9800 Non-Energy, ResCom & others (Commercial & Others) |
| | 1A4b | Residential | #7100 Final Energy Consumption, Residential |
| | | | #9800 Non-Energy, ResCom & others (Residential) |
| | 1A4c | Agriculture/Forestry/Fisheries | #6110 Final Energy Consumption, Agruculture, Forestry & Fishery |
| | | | #9610 Non-Energy, Non-Manufacturing Industry |
| 1A5 | | Other | |
| | 1A5a | Stationary | - - |
| | 1A5b | Mobile | - - |

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' are feedstocks of town gas production, and was not used to purposes combustion. 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 feedstocks for oil products, and was 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).

### *References*

Environmental Agency , *The Estimation of $CO_2$ Emissions in Japan*, 1992

Research Institute of Economy, Trade & Industry, Kazunari Kaino, *Interpretation of General Energy Statistics*, 2008

# Annex 3. Other Detailed Methodological Descriptions for Individual Source or Sink Categories

## 3.1. Methodology for Estimating Emissions of Precursors

In addition to the greenhouse gases (e.g., $CO_2$, $CH_4$, $N_2O$, HFCs, PFCs, $SF_6$) reported under the Kyoto Protocol, Japan reports on the emissions of precursors (NOx, 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.

### 3.1.1. Energy Sector

#### 3.1.1.1. Stationary Combustion (1.A.1., 1.A.2., 1.A.4.: $NO_x$, CO, NMVOC, $SO_2$)

#### 3.1.1.1.a. Facilities emitting soot and smokes

***1） $NO_x$ and $SO_2$***

● ***Methodology for Estimating Emissions***

*Research of Air Pollutant Emissions from Stationary Sources* (“*MAP Survey*”) by the Ministry of the Environment (MoE) was used as the basis for estimation of $NO_x$ and $SO_2$ emitted from fixed sources (see Page 3.12 for details of the survey). 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 *MAP Survey*:

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 *MAP Survey* 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 *MAP Survey*, 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 *MAP Survey* to determine $SO_2$ emissions in the energy sector.

| |
|---|
| *Calculation of $SO_x$ emissions (in the Industrial Processes sector)* |
| $SO_x$ emissions [t-$SO_x$] = Sulfur content per material [t-$SO_x$] × (1 – desulphurization 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 *MAP Survey*.

➢ ***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 *MAP Survey* data were used for all items.

Denitrification efficiency: ($NO_x$ volume before treatment – $NO_x$ volume after treatment) / volume of smoke and soot

➢ ***Desulphurization rate***

Desulphurization rate was calculated by the following equation:

| |
|---|
| *Calculation of desulphurization rate* <br> Desulphurization rate [%] <br> = Desulphurization efficiency [%] × (Hours operation of desulphurization unit [h/yr] / Hours operation of furnace [h/yr]) × (Processing capacity of desulphurization unit [$m^3$/yr] / max exhaust gas emission [$m^3$/yr]) |

The *MAP Survey* data were used for all items.

Desulphurization 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 *MAP Survey* 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 *MAP Survey*, 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 *MAP Survey*, 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.

### 3.1.1.1.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 $SO_x$***

Emission factors for $NO_x$ and $SO_x$ 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 *MAP Survey* 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 $SO_X$, energy consumption by small facilities per fuel type was calculated by subtracting energy consumption per fuel type, identified by the *MAP Survey*, 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 *MAP Survey* 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.

### 3.1.1.1.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 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 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.

### 3.1.1.1.d. Incineration of waste for energy purposes and with energy recovery

Emissions of NOx, 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 "3.1.5. Wastes".

### 3.1.1.2. Mobile Combustion (1.A.3: $NO_x$, CO, NMVOC, and $SO_2$)

### 3.1.1.2.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 1 $NO_x$ emission factors for automobiles

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Light Vehicle | gNOx/km | 0.230 | 0.159 | 0.157 | 0.097 | 0.083 | 0.070 |
| | Passenger Vehicle (including LPG) | gNOx/km | 0.237 | 0.203 | 0.199 | 0.094 | 0.082 | 0.070 |
| | Light Cargo Truck | gNOx/km | 0.873 | 0.658 | 0.375 | 0.218 | 0.192 | 0.166 |
| | Small Cargo Truck | gNOx/km | 1.115 | 0.897 | 0.478 | 0.094 | 0.078 | 0.065 |
| | Regular Cargo Truck | gNOx/km | 1.833 | 1.093 | 0.560 | 0.061 | 0.050 | 0.043 |
| | Bus | gNOx/km | 4.449 | 3.652 | 2.438 | 0.080 | 0.066 | 0.053 |
| | Special Vehicle | gNOx/km | 1.471 | 0.873 | 0.429 | 0.099 | 0.077 | 0.063 |
| Diesel | Passenger Vehicle | gNOx/km | 0.636 | 0.526 | 0.437 | 0.428 | 0.367 | 0.336 |
| | Small Cargo Truck | gNOx/km | 1.326 | 1.104 | 1.005 | 0.924 | 0.829 | 0.743 |
| | Regular Cargo Truck | gNOx/km | 5.352 | 4.586 | 4.334 | 4.308 | 3.994 | 3.752 |
| | Bus | gNOx/km | 4.226 | 3.830 | 3.597 | 3.939 | 3.619 | 3.377 |
| | Special Vehicle | gNOx/km | 3.377 | 2.761 | 2.152 | 3.427 | 3.135 | 2.896 |

*Source: Ministry of the Environment*

Table 2 CO emission factors for automobiles

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Light Vehicle | gCO/km | 1.749 | 1.549 | 1.543 | 1.211 | 1.143 | 1.082 |
| | Passenger Vehicle (including LPG) | gCO/km | 2.325 | 2.062 | 2.034 | 1.150 | 1.092 | 1.040 |
| | Light Cargo Truck | gCO/km | 10.420 | 8.540 | 5.508 | 3.074 | 2.670 | 2.391 |
| | Small Cargo Truck | gCO/km | 9.656 | 10.079 | 8.309 | 2.172 | 1.849 | 1.585 |
| | Regular Cargo Truck | gCO/km | 12.624 | 10.601 | 8.950 | 1.924 | 1.643 | 1.550 |
| | Bus | gCO/km | 26.209 | 25.079 | 21.938 | 2.062 | 1.810 | 1.477 |
| | Special Vehicle | gCO/km | 12.466 | 10.666 | 8.924 | 1.757 | 1.515 | 1.347 |
| Diesel | Passenger Vehicle | gCO/km | 0.480 | 0.432 | 0.429 | 0.362 | 0.300 | 0.268 |
| | Small Cargo Truck | gCO/km | 0.975 | 0.896 | 0.808 | 0.576 | 0.511 | 0.459 |
| | Regular Cargo Truck | gCO/km | 3.221 | 2.988 | 2.440 | 1.903 | 1.611 | 1.399 |
| | Bus | gCO/km | 2.579 | 2.534 | 2.200 | 1.810 | 1.496 | 1.284 |
| | Special Vehicle | gCO/km | 2.109 | 1.893 | 1.297 | 1.427 | 1.195 | 1.016 |

*Source: Ministry of the Environment*

Table 3 NMVOC emission factors for automobiles

| Fuel | Vehicle Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| Gasoline | Light Vehicle | gHC/km | 0.128 | 0.050 | 0.048 | 0.042 | 0.036 | 0.030 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.077 | 0.030 | 0.029 | 0.025 | 0.021 | 0.018 |
| | Passenger Vehicle (including LPG) | gHC/km | 0.189 | 0.112 | 0.104 | 0.031 | 0.028 | 0.024 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.113 | 0.067 | 0.062 | 0.019 | 0.017 | 0.014 |
| | Light Cargo Truck | gHC/km | 1.058 | 0.610 | 0.274 | 0.164 | 0.144 | 0.124 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.635 | 0.366 | 0.165 | 0.099 | 0.086 | 0.074 |
| | Small Cargo Truck | gHC/km | 1.188 | 0.882 | 0.346 | 0.063 | 0.051 | 0.041 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.713 | 0.529 | 0.208 | 0.038 | 0.030 | 0.024 |
| | Regular Cargo Truck | gHC/km | 1.658 | 0.959 | 0.471 | 0.048 | 0.039 | 0.035 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.995 | 0.575 | 0.283 | 0.029 | 0.023 | 0.021 |
| | Bus | gHC/km | 3.604 | 3.164 | 2.193 | 0.059 | 0.045 | 0.034 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 2.162 | 1.899 | 1.316 | 0.036 | 0.027 | 0.020 |
| | Special Vehicle | gHC/km | 1.619 | 0.786 | 0.317 | 0.053 | 0.040 | 0.032 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.972 | 0.472 | 0.190 | 0.032 | 0.024 | 0.019 |
| Diesel | Passenger Vehicle | gHC/km | 0.109 | 0.098 | 0.097 | 0.086 | 0.072 | 0.066 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.065 | 0.059 | 0.058 | 0.052 | 0.043 | 0.039 |
| | Small Cargo Truck | gHC/km | 0.389 | 0.343 | 0.258 | 0.177 | 0.141 | 0.113 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.233 | 0.206 | 0.155 | 0.106 | 0.084 | 0.068 |
| | Regular Cargo Truck | gHC/km | 1.634 | 1.488 | 1.040 | 0.719 | 0.587 | 0.491 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.980 | 0.893 | 0.624 | 0.431 | 0.352 | 0.295 |
| | Bus | gHC/km | 1.273 | 1.255 | 0.995 | 0.713 | 0.553 | 0.449 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.764 | 0.753 | 0.597 | 0.428 | 0.332 | 0.269 |
| | Special Vehicle | gHC/km | 1.101 | 0.965 | 0.526 | 0.509 | 0.405 | 0.329 |
| | | % | 60% | 60% | 60% | 60% | 60% | 60% |
| | | gNMVOC/km | 0.661 | 0.579 | 0.316 | 0.305 | 0.243 | 0.197 |

Top row: THC emission factors;

Middle row: Percentage of NMVOC in the THC emission;

*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 4 Sulfur content (by weight) by fuel type

| Fuel | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Gasolin | % | 0.008% | 0.008% | 0.008% | 0.008% | 0.008% | 0.000% |
| Diesel | % | 0.350% | 0.136% | 0.136% | 0.136% | 0.136% | 0.000% |
| LPG | % | 0.002% | 0.002% | 0.002% | 0.002% | 0.002% | 0.000% |

*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 NOx, CO, NMVOCs, and $SO_2$ from natural gas vehicles and motorcycles are reported as "NE".

## 3.1.1.2.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 5 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 NOx, CO, and NMVOCs from aviation fuel consumption are reported as “NE”.

### 3.1.1.2.c. Navigation (1.A.3.d.: $NO_x$, 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 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 6 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 and Transport).

### 3.1.1.2.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 7 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.

### 3.1.1.3. Fugitive emissions from fuels (1.B.: NMVOC)

#### 3.1.1.3.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 Served 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.

#### 3.1.1.3.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 8 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.

#### 3.1.1.3.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 calculated.

#### 3.1.1.3.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 9 shows the relationship between the NMVOC emission sources and activity data.

Table 9 Relationship between the NMVOC 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 |

### 3.1.1.3.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 10 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 fuel delivery [t]
> = $\Sigma_{Prefecture}$ {(gasoline sales per prefecture [ML] × emission factor for fuel delivery [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 FY 2001, the number of service stations registered under law was used.

### 3.1.2. Industrial Processes

#### 3.1.2.1. 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 *MAP Survey*, 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:

> <u>Calculation of $SO_x$ emissions (in the Industrial Processes sector)</u>
>
> $SO_x$ emissions [t-$SO_x$]
>
> = Sulfur content per material [t-$SO_x$] × (1 – desulphurization 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 *MAP Survey*.

➢ ***Denitrification rate***

The denitrification rate was calculated by the following equation:

> <u>Calculation of denitrification rate</u>
>
> 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 *MAP Survey* data were used for all items.

Denitrification efficiency: ($NO_x$ volume before treatment – $NO_x$ volume after treatment) / volume of smoke and soot

➢ ***Desulphurization rate***

The desulphurization rate was calculated by the following equation:

> <u>Calculation of desulphurization rate</u>
>
> Desulphurization rate [%]
>
> = Desulphurization efficiency [%] × (Hours operation of desulphurization unit [h/yr] / Hours operation of furnace [h/yr]) × (Processing capacity of desulphurization unit [$m^3$/yr] / max. exhaust gas emission [$m^3$/yr])

The *MAP Survey* data were used for all items.

Desulphurization 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 *MAP Survey* 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 *MAP Survey*, 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 *MAP Survey*, by the consumption volume of the material.

### 3.1.2.2. Other (2.G.: NMVOC)

#### 3.1.2.2.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 11 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.

#### 3.1.2.2.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.

#### 3.1.2.2.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.

### 3.1.3. Sectors that use solvents and other products

#### 3.1.3.1. 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 NMOVC 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.

<u>*Calculation of annual consumption of paint solvent A in Year X*</u>
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 12 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 |

### 3.1.3.2. Degreasing, dry cleaning (3.B.: NMVOC)

### 3.1.3.2.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.

#### 3.1.3.2.b. NMVOCs emissions from dry cleaning

- ***Methodology for Estimating Emissions***

NMVOCs emissions from dry cleaning were calculated on the assumption that the volume of NMOVC 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]

= $\Sigma_{\text{petroleum-based solvent/tetrachloroethylene}}$ {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)}

### 3.1.3.3. Chemical products, manufacture and processing (3.C.: NMVOC)

#### 3.1.3.3.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).

- ***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.

Table 13 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)*

### 3.1.3.3.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 14 Emission factors for solvents used as materials in 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***

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.

### 3.1.3.3.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.

### 3.1.3.3.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.

### 3.1.3.3.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 15 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)

#### 3.1.3.3.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).

### 3.1.3.4. Other (3.D.: NMVOC)

#### 3.1.3.4.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.

## 3.1.4. Agriculture

### 3.1.4.1. Field burning of agricultural residues (4.F.)

#### 3.1.4.1.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 16 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 Kan'no, "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 17 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 Kan'no, "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 18 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 Kan'no, "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 obtained by using the following equations, which were used in 4F.1. to calculate $CH_4$ and $N_2O$ emissions from the burning of agricultural residue, to allocate the amounts of rice plants, wheat (for seed), and barley (for seed) burned to the amounts of rice straw, chaff, and wheat straw burned.

| |
|---|
| Amount of rice straw burned = amount of rice plants burned × 0.5 |
| Amount of chaff burned = amount of rice plants burned × 0.5 |
| Amount of wheat/barley straw burned = (amounts of wheat and barley burned) × 0.5 |

Note: Based on the judgment of specialists, the ratios of straw to chaff and rice plants to wheat/barley were set to 1:1.

### 3.1.5. Wastes

#### 3.1.5.1. Waste incineration (6.C.)

#### 3.1.5.1.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 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***

➢ ***$NO_X$, $SO_2$***

Emission factors were established for each incinerator type by using the emission volume and volume of treated waste identified in the *MAP Survey*. (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 *MAP Survey* classified the incinerators into two classes (Continuous and Batch), this report classifies incinerators into three classes ("Continuous", "Semi-continuous", and "Batch") by dividing the Continuous system and assigning those which operated for less than 3,000 hours to the "Semi-continuous" class.

Table 19 $NO_x$ and $SO_2$ emission factors for municipal waste incineration by facility type

| | Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| NOx | Municipal Waste Incinerator(Cont.) | kg-NOx/t | 1.238 | 1.213 | 1.127 | 1.127 | 1.127 | 1.127 |
| | Municipal Waste Incinerator(Semi-Cont.) | kg-NOx/t | 1.055 | 1.226 | 1.226 | 1.226 | 1.226 | 1.226 |
| | Municipal Waste Incinerator(Batch) | kg-NOx/t | 1.137 | 1.918 | 1.850 | 1.850 | 1.850 | 1.850 |
| $SO_2$ | Municipal Waste Incinerator(Cont.) | kg-$SO_2$/t | 0.555 | 0.539 | 0.361 | 0.361 | 0.361 | 0.361 |
| | Municipal Waste Incinerator(Semi-Cont.) | kg-$SO_2$/t | 0.627 | 1.141 | 0.712 | 0.712 | 0.712 | 0.712 |
| | Municipal Waste Incinerator(Batch) | kg-$SO_2$/t | 1.073 | 1.625 | 1.714 | 1.714 | 1.714 | 1.714 |

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, 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" by weighting the average of incinerated volume for each furnace.

Table 20 CO emission factors for municipal waste incineration by facility type

| | Furnace Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| CO | Continuous Incinerator | gCO/t | 557 | 557 | 555 | 552 | 552 | 552 |
| | Semi-Continuous Incinerator | gCO/t | 548 | 548 | 567 | 592 | 607 | 607 |
| | Batch type Incinerator | gCO/t | 8,237 | 8,237 | 8,298 | 8,341 | 8,344 | 8,344 |

* The data for 2000 were used for 2001 and subsequent years.

*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 material by Japan Environmental Sanitation Center and Institute of Behavioral Science, which estimated $CH_4$ and NMVOC emissions per unit calorific value.

Table 21 NMVOC emission factors for municipal waste incineration by facility type

| | Furnace Type | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| NMVOC | Continuous Incinerator | gNMVOC/t | 0.925 | 0.925 | 0.932 | 0.947 | 0.948 | 0.948 |
| | Semi-Continuous Incinerator | gNMVOC/t | 7.8 | 7.8 | 8.5 | 9.3 | 9.8 | 9.8 |
| | Batch type Incinerator | gNMVOC/t | 9.1 | 9.1 | 9.5 | 9.8 | 9.8 | 9.8 |

The data for 2000 were used for 2001 and subsequent years.

*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 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.

#### 3.1.5.1.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 *MAP Survey*. 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 22 $NO_x$ and $SO_2$ emission factors for industrial waste by facility type

| | Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|
| NOx | "Fuel Wood 23" | kg-NOx/t | 1.545 | 1.312 | 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 |
| $SO_2$ | "Fuel Wood 23" | kg-$SO_2$/t | 1.528 | 1.274 | 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 |

* The data for 1999 were used for 2000 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 23 CO emission factors for industrial waste incinerators by operation type

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Waste Paper, Waste Wood | gCO/t | 1,334 | 1,334 | 1,334 | 1,334 | 1,334 | 1,334 |
| Waste Oil | gCO/t | 127 | 127 | 127 | 127 | 127 | 127 |
| Waste Plastics | gCO/t | 1,790 | 1,790 | 1,790 | 1,790 | 1,790 | 1,790 |
| Sludge | gCO/t | 2,285 | 2,285 | 2,285 | 2,285 | 2,285 | 2,285 |
| Waste textile | gCO/t | 1,334 | 1,334 | 1,334 | 1,334 | 1,334 | 1,334 |
| Animal and Plant residues | gCO/t | 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 24 NMVOC emission factors for industrial waste incineration by facility type

| Item | Unit | 1990 | 1995 | 2000 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Waste Paper, Waste Wood | gNMVOC/t | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 |
| Waste Oil | gNMVOC/t | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 |
| Waste Plastics | gNMVOC/t | 3.40 | 3.40 | 3.40 | 3.40 | 3.40 | 3.40 |
| Sludge | gNMVOC/t | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 | 1.61 |
| Waste textile | gNMVOC/t | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 |
| Animal and Plant residues | gNMVOC/t | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 | 2.48 |

Source*: Report on Screening Survey Regarding Measures to Counter Global Warming (Japan Environmental Sanitation Center, 1989)*

*Study of Establishment of Methodology for Estimation of Hydrocarbon Emissions (Institute of Behavioral Science, 1984)*

● ***Activity Data***

The activity data used the incineration 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.

### 3.1.5.1.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. Since the calorific value of RPF was updated this year, its emission factor has also been changed accordingly.

Table 25 CO emission factors from incineration in conjunction with use of waste as fuel and raw material

| Application | Units | Waste oil | RDF | RPF | Waste tires | Waste plastics | Waste wood |
|---|---|---|---|---|---|---|---|
| Simple incineration | kgCO/t | 0.13 | 1.79 | 1.79 | 1.79 | | |
| Boilers | kgCO/t | 0.052 | 0.24 | 0.39 | 0.28 | 0.03 | 3.64 |
| Cement kilns | kgCO/t | 49.1 | 19.8 | 32.2 | 23.0 | 32.2 | |
| Other furnaces | kgCO/t | 0.052 | 0.24 | 0.39 | 0.28 | | |
| Pyrolysis furnaces | kgCO/t | | | | 0.021 | | |
| Gasification | kgCO/t | | | | 0.015 | | |

➢ ***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. Since the calorific value of RPF was updated this year, its emission factor has also been changed accordingly.

Table 26 NMVOC emissions factors from incineration in conjunction with use of waste as fuel and raw material

| Application | Units | Waste oil | RDF | RPF | Waste tires | Waste plastics | Waste wood |
|---|---|---|---|---|---|---|---|
| Boilers | kgNMVOC/t | 0.015 | 0.00027 | 0.00043 | 0.00031 | 0.010 | 0.12 |
| Cement kilns | kgNMVOC/t | 0.048 | 0 | 0.043 | 0.031 | 0.043 | |
| Other furnaces | kgNMVOC/t | 0 | 0 | 0 | 0 | | |
| Pyrolysis furnaces | kgNMVOC/t | | | | 0.0051 | | |
| Gasification | kgNMVOC/t | | | | 0.0089 | | |

● ***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.

### 3.1.6. Other sectors

#### 3.1.6.1. 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).

## 4.1. Difference in Energy Consumption

As shown in Table 1, fluctuations of difference of energy consumption between the reference approach and the sectoral approach during 1990-2007 ranges between -1.22% and 0.55%. It is relatively low compared to the inventories from other countries.

Difference of solid fuels in 2004 was quite large value, because of coal (Imported Steam Coal [$130]) stock change increasing.

Table 1 Comparison of Energy Consumption

[10^18J]

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Approach** | | | | | | | | | | |
| Liquid fuels | 9,528 | 10,113 | 9,429 | 9,154 | 9,160 | 9,064 | 8,772 | 8,802 | 8,204 | 8,203 |
| Solid fuels | 3,291 | 3,626 | 4,189 | 4,281 | 4,424 | 4,553 | 4,981 | 4,748 | 4,806 | 5,020 |
| Gaseous fuels | 2,088 | 2,526 | 3,125 | 3,121 | 3,206 | 3,355 | 3,343 | 3,378 | 3,735 | 4,070 |
| Other fuels | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Total RA** | **14,908** | **16,265** | **16,742** | **16,557** | **16,791** | **16,972** | **17,096** | **16,927** | **16,744** | **17,293** |
| **Sectoral Approach** | | | | | | | | | | |
| Liquid fuels | 9,550 | 10,051 | 9,450 | 9,133 | 9,275 | 9,094 | 8,934 | 8,903 | 8,390 | 8,402 |
| Solid fuels | 3,354 | 3,635 | 4,118 | 4,221 | 4,485 | 4,607 | 4,724 | 4,811 | 4,791 | 4,959 |
| Gaseous fuels | 2,106 | 2,548 | 3,136 | 3,137 | 3,238 | 3,371 | 3,371 | 3,368 | 3,756 | 4,106 |
| Other fuels | NE | NE | NE | NE | NE | NE | NE | NE | NE | NE |
| **Total** | **15,010** | **16,234** | **16,705** | **16,490** | **16,998** | **17,072** | **17,029** | **17,082** | **16,936** | **17,466** |
| Difference (%) | | | | | | | | | | |
| *Liquid fuels* | -0.22% | 0.61% | -0.23% | 0.23% | -1.24% | -0.33% | -1.81% | -1.14% | -2.22% | -2.37% |
| *Solid fuels* | -1.86% | -0.24% | 1.72% | 1.43% | -1.36% | -1.18% | 5.44% | -1.32% | 0.32% | 1.23% |
| *Gaseous fuels* | -0.88% | -0.87% | -0.38% | -0.49% | -0.97% | -0.48% | -0.83% | 0.29% | -0.57% | -0.86% |
| *Other fuels* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| ***Total*** | **-0.68%** | **0.19%** | **0.22%** | **0.40%** | **-1.22%** | **-0.59%** | **0.39%** | **-0.91%** | **-1.13%** | **-0.99%** |

## 4.2. Difference in $CO_2$ Emissions

As shown in Table 2, fluctuations of a difference of $CO_2$ emissions between -2.18% and -0.07%. Emissions from wastes used for energy and from the incineration of wastes with energy recovery, which had been reported in waste sector (6.C.) in previous submissions, are reported in the energy sector (1.A.) in the 2009 inventory submission. Therefore, the difference in $CO_2$ emissions between the reference approach and the sectoral approach are changed.

Difference of solid fuels in 2004 was quite large value, because of coal (Imported Steam Coal [$130]) stock change increasing.

Table 2 Comparison of $CO_2$ Emissions

[Tg $CO_2$]

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reference Approach** | | | | | | | | | | |
| Liquid fuels | 648.2 | 687.0 | 641.8 | 623.0 | 623.1 | 616.8 | 597.3 | 599.1 | 558.2 | 558.8 |
| Solid fuels | 296.2 | 326.0 | 378.7 | 386.7 | 400.1 | 411.7 | 451.1 | 429.7 | 435.0 | 454.5 |
| Gaseous fuels | 103.2 | 124.9 | 154.5 | 154.3 | 158.5 | 165.9 | 165.3 | 167.0 | 184.7 | 201.3 |
| Other fuels | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **Total RA** | **1,048** | **1,138** | **1,175** | **1,164** | **1,182** | **1,194** | **1,214** | **1,196** | **1,178** | **1,215** |
| **Sectoral Approach** | | | | | | | | | | |
| Liquid fuels | 646.2 | 677.3 | 635.1 | 613.1 | 622.9 | 611.4 | 600.4 | 598.2 | 562.5 | 564.1 |
| Solid fuels | 308.6 | 331.7 | 376.5 | 385.0 | 409.8 | 419.9 | 431.4 | 438.2 | 437.0 | 451.9 |
| Gaseous fuels | 104.3 | 126.2 | 155.3 | 155.3 | 160.4 | 167.0 | 166.9 | 166.8 | 186.4 | 203.3 |
| Other fuels | 8.9 | 10.4 | 13.1 | 14.2 | 15.1 | 16.0 | 15.8 | 15.4 | 15.6 | 16.0 |
| **Total** | **1,068** | **1,146** | **1,180** | **1,168** | **1,208** | **1,214** | **1,215** | **1,219** | **1,202** | **1,235** |
| Difference (%) | | | | | | | | | | |
| *Liquid fuels* | 0.31% | 1.42% | 1.05% | 1.63% | 0.04% | 0.88% | -0.52% | 0.15% | -0.77% | -0.93% |
| *Solid fuels* | -4.02% | -1.73% | 0.57% | 0.44% | -2.36% | -1.95% | 4.57% | -1.96% | -0.47% | 0.57% |
| *Gaseous fuels* | -1.02% | -1.03% | -0.50% | -0.63% | -1.13% | -0.69% | -0.97% | 0.11% | -0.92% | -0.99% |
| *Other fuels* | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| ***Total*** | **-1.91%** | **-0.68%** | **-0.43%** | **-0.30%** | **-2.18%** | **-1.64%** | **-0.07%** | **-1.88%** | **-1.97%** | **-1.67%** |

## 4.3. 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.

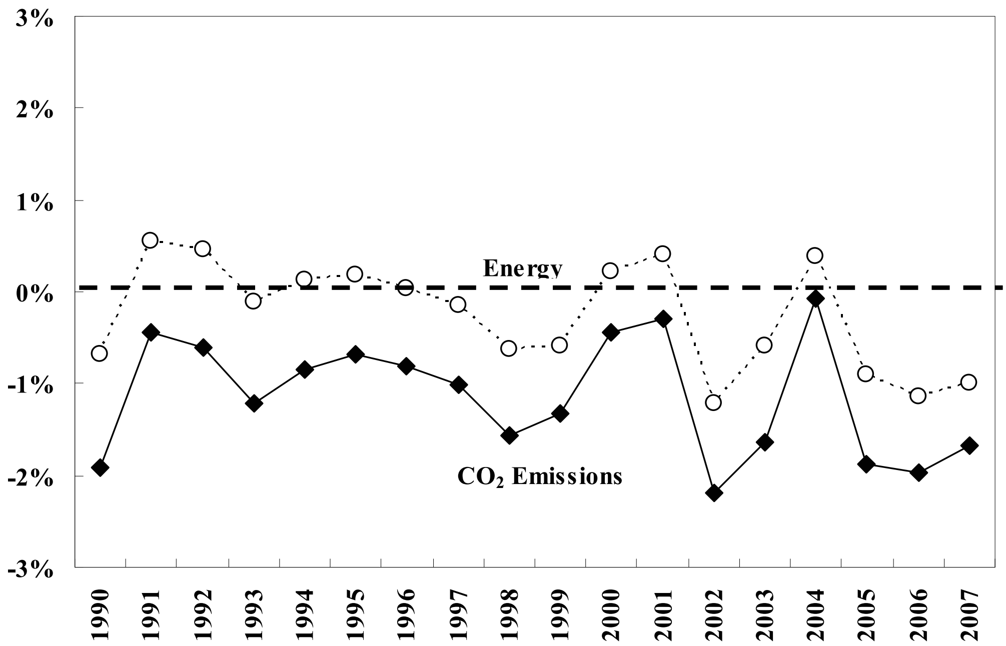



Figure 1 Trends in Difference of Energy Consumption and $CO_2$ Emissions

## 4.4. 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*).

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

In the current estimation of reference approach, it was assumed that the amount of energy subtracted the energy amount for non-energy use from the national energy amount supplied was completely combusted. However, in real situations, some of the energy amount combusted is left without being combusted. The increase or decrease of the remaining energy amount were not considered in the current estimation of 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 amount of carbon may not be fully taken into account 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 large-scale energy conversion such as power production, heat generation, and coal and oil product manufacturing. It also represents changes in coal and oil products through only very simple operations.

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 3 Comparison of $CO_2$ emissions (detail)

[Gg-$CO_2$]

| | 1990 | 1995 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|---|---|---|
| **RA** | **1,047,665** | **1,137,864** | **1,174,906** | **1,163,992** | **1,181,761** | **1,194,369** | **1,213,677** | **1,195,817** | **1,177,816** | **1,214,608** |
| Liquid fuels | 648,201 | 686,979 | 641,758 | 623,033 | 623,126 | 616,782 | 597,298 | 599,138 | 558,156 | 558,844 |
| Solid fuels | 296,228 | 325,991 | 378,670 | 386,654 | 400,092 | 411,694 | 451,087 | 429,657 | 434,980 | 454,488 |
| Gaseous fuels | 103,236 | 124,893 | 154,478 | 154,304 | 158,543 | 165,894 | 165,292 | 167,022 | 184,680 | 201,276 |
| Other fuels | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **SA** | **1,068,019** | **1,145,682** | **1,180,026** | **1,167,535** | **1,208,149** | **1,214,241** | **1,214,534** | **1,218,738** | **1,201,534** | **1,235,227** |
| Liquid fuels | 646,223 | 677,349 | 635,121 | 613,057 | 622,889 | 611,372 | 600,423 | 598,218 | 562,478 | 564,064 |
| Solid fuels | 308,620 | 331,721 | 376,537 | 384,963 | 409,770 | 419,869 | 431,353 | 438,247 | 437,025 | 451,893 |
| Gaseous fuels | 104,301 | 126,198 | 155,261 | 155,279 | 160,359 | 167,045 | 166,918 | 166,837 | 186,389 | 203,287 |
| Other fuels | 8,875 | 10,415 | 13,108 | 14,236 | 15,131 | 15,955 | 15,840 | 15,436 | 15,643 | 15,983 |
| **RA-SA** | **-20,354** | **-7,818** | **-5,120** | **-3,543** | **-26,389** | **-19,872** | **-856** | **-22,921** | **-23,719** | **-20,620** |
| Liquid fuels | 1,978 | 9,631 | 6,638 | 9,976 | 236 | 5,410 | -3,124 | 920 | -4,322 | -5,221 |
| Solid fuels | -12,392 | -5,730 | 2,133 | 1,692 | -9,678 | -8,175 | 19,733 | -8,590 | -2,045 | 2,595 |
| Gaseous fuels | -1,065 | -1,304 | -783 | -975 | -1,816 | -1,152 | -1,626 | 185 | -1,709 | -2,011 |
| Other fuels | -8,875 | -10,415 | -13,108 | -14,236 | -15,131 | -15,955 | -15,840 | -15,436 | -15,643 | -15,983 |
| **Statistical Discrepancy** | **-11,299** | **4,490** | **-1,700** | **-1,523** | **-11,915** | **-8,074** | **-10,165** | **-15,829** | **-10,516** | **-15,259** |
| Liquid fuels | -3,708 | 3,839 | -5,664 | -5,292 | -12,641 | -10,667 | -15,986 | -15,622 | -18,633 | -22,611 |
| Solid fuels | -7,630 | 415 | 3,473 | 3,323 | 276 | 2,248 | 5,334 | -685 | 8,638 | 7,425 |
| Gaseous fuels | 39 | 236 | 491 | 446 | 450 | 346 | 488 | 478 | -521 | -73 |
| **Other Conversions & Blending** | **-2,828** | **-3,076** | **-1,189** | **-1,277** | **-782** | **-775** | **-601** | **-1,104** | **-1,224** | **-1,464** |
| Liquid fuels | 803 | 1,058 | 1,119 | 1,091 | 1,136 | 1,171 | 1,161 | 1,213 | 1,175 | 1,117 |
| Solid fuels | -2,807 | -3,078 | -1,121 | -1,168 | -709 | -709 | -546 | -1,059 | -1,131 | -1,361 |
| Gaseous fuels | -825 | -1,056 | -1,186 | -1,201 | -1,210 | -1,237 | -1,216 | -1,258 | -1,267 | -1,220 |
| **Stock Change** | **2,286** | **768** | **2,650** | **4,206** | **-9,464** | **-7,856** | **15,924** | **-3,429** | **-5,706** | **-3,971** |
| Liquid fuels | 788 | 1,311 | -976 | 1,209 | -3,753 | -1,853 | -2,369 | 272 | 2,233 | -1,293 |
| Solid fuels | 1,515 | -353 | 3,359 | 2,850 | -5,028 | -6,126 | 18,808 | -5,084 | -8,421 | -2,334 |
| Gaseous fuels | -18 | -190 | 268 | 148 | -683 | 123 | -515 | 1,383 | 482 | -344 |
| **Other Input/Output** | **-895** | **-642** | **2,106** | **623** | **1,878** | **2,010** | **1,625** | **2,665** | **-1,355** | **1,224** |
| Liquid fuels | -895 | -642 | 2,106 | 623 | 1,878 | 2,010 | 1,625 | 2,665 | -1,355 | 1,224 |
| Solid fuels | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gaseous fuels | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Oil Products** | **1,257** | **1,057** | **6,121** | **8,664** | **9,025** | **10,777** | **8,201** | **10,211** | **10,724** | **14,833** |
| Liquid fuels | 1,518 | 1,351 | 6,476 | 9,032 | 9,399 | 11,162 | 8,583 | 10,629 | 11,128 | 15,207 |
| Solid fuels | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gaseous fuels | -261 | -294 | -355 | -368 | -374 | -385 | -382 | -418 | -403 | -374 |
| **Total** | **-11,478** | **2,597** | **7,988** | **10,693** | **-11,258** | **-3,917** | **14,983** | **-7,485** | **-8,076** | **-4,637** |
| Liquid fuels | -1,493 | 6,917 | 3,060 | 6,663 | -3,981 | 1,822 | -6,986 | -843 | -5,453 | -6,357 |
| Solid fuels | -8,921 | -3,016 | 5,711 | 5,005 | -5,461 | -4,587 | 23,595 | -6,828 | -914 | 3,731 |
| Gaseous fuels | -1,064 | -1,304 | -783 | -975 | -1,816 | -1,152 | -1,626 | 185 | -1,709 | -2,011 |
| **(RA-SA)-(Total)** | **-8,875** | **-10,415** | **-13,108** | **-14,236** | **-15,131** | **-15,955** | **-15,840** | **-15,436** | **-15,643** | **-15,983** |
| Liquid fuels | 3,471 | 2,714 | 3,578 | 3,313 | 4,218 | 3,588 | 3,862 | 1,763 | 1,130 | 1,136 |
| Solid fuels | -3,471 | -2,714 | -3,578 | -3,313 | -4,218 | -3,588 | -3,862 | -1,763 | -1,130 | -1,136 |
| Gaseous fuels | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other fuels | -8,875 | -10,415 | -13,108 | -14,236 | -15,131 | -15,955 | -15,840 | -15,436 | -15,643 | -15,983 |

# Annex 5. Assessment of Completeness and (Potential) Sources and Sinks of Greenhouse Gas Emissions and Removals Excluded

## 5.1. 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 or FCCC/CP/2002/8) 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.

## 5.2. 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 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.

[1] These were called "standard indicators" in FCCC/CP/1999/7, but were changed to "notation keys" in FCCC/CP/2002/8.

Table 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).

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 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.

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 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). |

## 5.3. Decision Tree for Application of Notation Keys

Decision tree for the application of notation keys, based on UNFCCC reporting Guidelines (FCCC/CP/1999/7 or FCCC/CP/2002/8) and the results of Committee for Greenhouse Gases Emissions Estimation Methods in 2002, is shown in Figure 1.

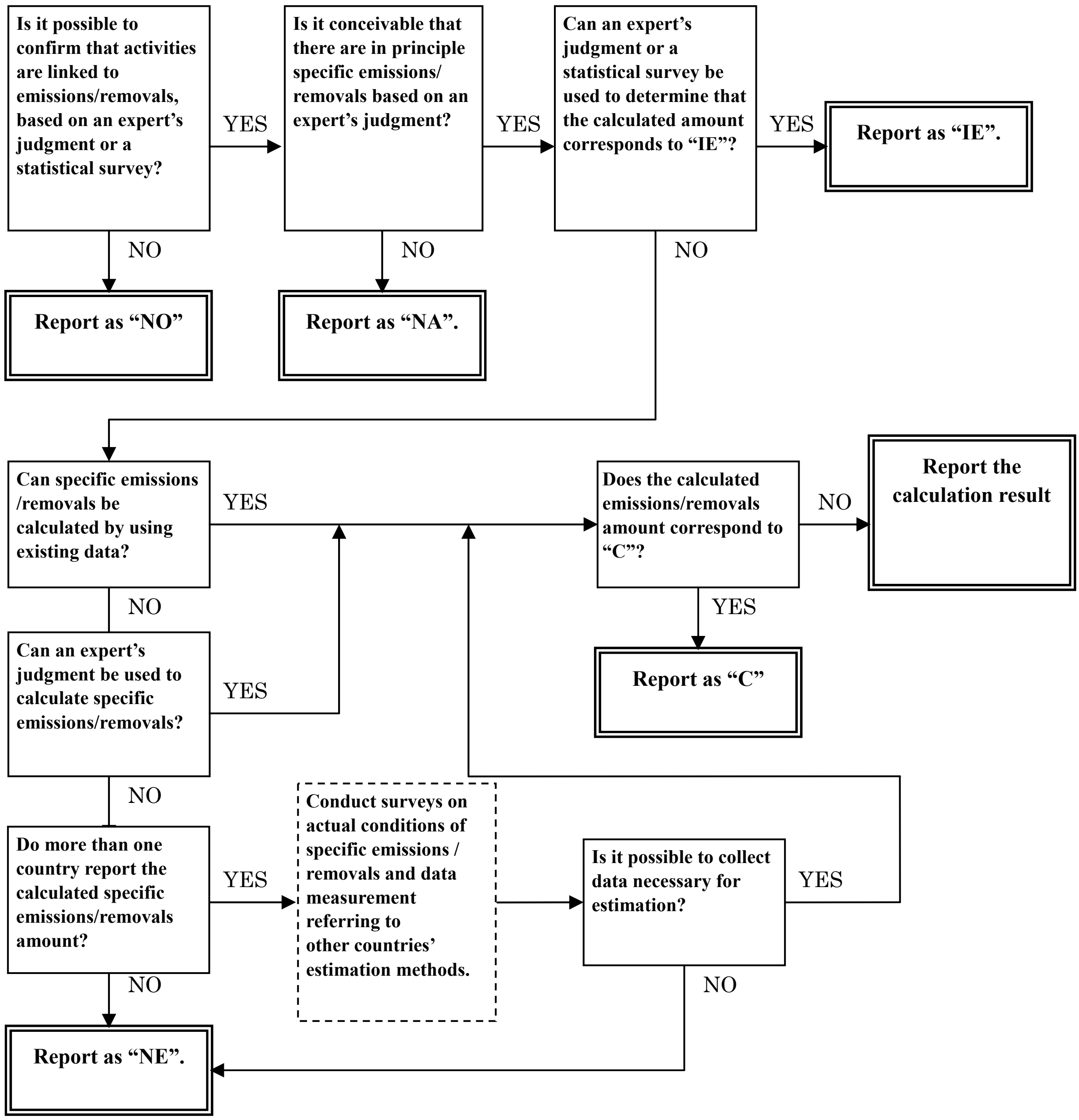



Figure 1 Decision tree for application of notation keys

## 5.4. 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. Note that the actual emissions 1990-1994 of HFCs, PFCs and $SF_6$ are not estimated.

Table 3 Dissolution of "NE" categories for 2007

| Code | Sector | Source category | | | | Gas |
|---|---|---|---|---|---|---|
| 1 | Energy | Fugitive Emissions from Fuels | Oil and Natural Gas | Natural Gas | Other Leakage(at industrial plants and power station) | $CO_2$ |
| 2 | Energy | Fugitive Emissions from Fuels | Oil and Natural Gas | Natural Gas | Other Leakage(at industrial plants and power station) | $CH_4$ |
| 3 | Energy | Fugitive Emissions from Fuels | Oil and Natural Gas | Natural Gas | Other Leakage(in residential and commercial sectors) | $CO_2$ |
| 4 | Energy | Fugitive Emissions from Fuels | Oil and Natural Gas | Natural Gas | Other Leakage(in residential and commercial sectors) | $CH_4$ |
| 5 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Fire Extinguishers | | Manufacturing/Stocks/Disposal | HFCs |
| 23 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Refrigeration and Air Conditioning Equipment | Commercial Refrigeration | Manufacturing/Stocks/Disposal | PFCs |
| 24 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Refrigeration and Air Conditioning Equipment | Automatic Vender Machine | Manufacturing/Stocks/Disposal | PFCs |
| 25 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Refrigeration and Air Conditioning Equipment | Transport Refrigeration | Manufacturing/Stocks/Disposal | PFCs |
| 26 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Refrigeration and Air Conditioning Equipment | Industrial Refrigeration | Manufacturing/Stocks/Disposal | PFCs |
| 27 | Industrial Processes | Consumption of Halocarbons and $SF_6$ | Refrigeration and Air Conditioning Equipment | Mobile Air-Conditioning | Manufacturing/Stocks/Disposal | PFCs |
| 30 | Solvent and Other Product Use | Other | Fire Extinguishers | | | $N_2O$ |
| 6 | Land - use Change and Forestry | Forest Land | Drainage of Soils | Mineral Soils | | $N_2O$ |
| 6 | Land - use Change and Forestry | Cropland | Agricultural lime apprication | Limestone | | $CO_2$ |
| 7 | Land - use Change and Forestry | Cropland | Agricultural lime apprication | Dolomite | | $CO_2$ |
| 8 | Land - use Change and Forestry | Grassland | Agricultural lime apprication | Limestone | | $CO_2$ |
| 9 | Land - use Change and Forestry | Grassland | Agricultural lime apprication | Dolomite | | $CO_2$ |
| 10 | Land - use Change and Forestry | Wetlands | Drainage of Soils | Mineral Soils | | $N_2O$ |

Table 4 "NE" categories for 2007

| Code | Sector | Source category | | | | Gas |
|---|---|---|---|---|---|---|
| 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 | Soda Ash | Soda Ash Use（Including desulfurization equipment） | | $CO_2$ |
| 10 | Industrial Processes | Mineral Products | Asphalt roofing | | | $CO_2$ |
| 11 | Industrial Processes | Mineral Products | Road Paving with Asphalt | | | $CO_2$ |
| 12 | Industrial Processes | Chemical Industry | Ammonia Production | | | $CH_4$ |
| 13 | Industrial Processes | Metal Production | Aluminium Production | | | $CH_4$ |
| 14 | Solvent and Other Product Use | Degreasing and Dry-Cleaning | | | | $CO_2$ |
| 15 | Solvent and Other Product Use | Other | Other Use of $N_2O$ | | | $CO_2$ |
| 16 | Solvent and Other Product Use | Other | Other Use of $N_2O$ | | | $N_2O$ |
| 17 | Agriculture | Enteric Fermentation | Poultry | | | $CH_4$ |
| 18 | Agriculture | Field Burning of Agricultural Residues | Other | | | $CH_4$ |
| 19 | Agriculture | Field Burning of Agricultural Residues | Other | | | $N_2O$ |
| 20 | Land - use Change and Forestry | Cropland | Cropland remaining Cropland | Dead Organic Matter | | $CO_2$ |
| 21 | Land - use Change and Forestry | Cropland | Land Converted to Cropland | Biomass Burning | Wildfires | $CO_2$ |
| 22 | Land - use Change and Forestry | Cropland | Land Converted to Cropland | Biomass Burning | Wildfires | $CH_4$ |
| 23 | Land - use Change and Forestry | Cropland | Land Converted to Cropland | Biomass Burning | Wildfires | $N_2O$ |
| 24 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Dead Organic Matter | | $CO_2$ |
| 25 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Wildfires | $CO_2$ |
| 26 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Wildfires | $CH_4$ |
| 27 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Wildfires | $N_2O$ |
| 28 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Controlled Burning | $CO_2$ |
| 29 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Controlled Burning | $CH_4$ |
| 30 | Land - use Change and Forestry | Grassland | Grassland remaining Grassland | Biomass Burning | Controlled Burning | $N_2O$ |
| 31 | Land - use Change and Forestry | Grassland | Land Converted to Grassland | Biomass Burning | Wildfires | $CO_2$ |
| 32 | Land - use Change and Forestry | Grassland | Land Converted to Grassland | Biomass Burning | Wildfires | $CH_4$ |
| 33 | Land - use Change and Forestry | Grassland | Land Converted to Grassland | Biomass Burning | Wildfires | $N_2O$ |
| 34 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Living Biomass | | $CO_2$ |
| 35 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Dead Organic Matter | | $CO_2$ |
| 36 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Soils | | $CO_2$ |
| 37 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Wildfires | $CO_2$ |
| 38 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Wildfires | $CH_4$ |
| 39 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Wildfires | $N_2O$ |
| 40 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Controlled Burning | $CO_2$ |
| 41 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Controlled Burning | $CH_4$ |
| 42 | Land - use Change and Forestry | Wetlands | Wetlands remaining Wetlands | Biomass Burning | Controlled Burning | $N_2O$ |

Table 4 “NE” categories for 2007 (cont.)

| Code | Sector | Source category | | | | Gas |
|---|---|---|---|---|---|---|
| 43 | Land - use Change and Forestry | Wetlands | Land converted to Wetlands | Soils | | $CO_2$ |
| 44 | Land - use Change and Forestry | Wetlands | Land converted to Wetlands | Biomass Burning | Wildfires | $CO_2$ |
| 45 | Land - use Change and Forestry | Wetlands | Land converted to Wetlands | Biomass Burning | Wildfires | $CH_4$ |
| 46 | Land - use Change and Forestry | Wetlands | Land converted to Wetlands | Biomass Burning | Wildfires | $N_2O$ |
| 47 | Land - use Change and Forestry | Settlements | Settlements remaining Settlements | Living Biomass Decrease | | $CO_2$ |
| 48 | Land - use Change and Forestry | Settlements | Settlements remaining Settlements | Dead Organic Matter | | $CO_2$ |
| 49 | Land - use Change and Forestry | Settlements | Settlements remaining Settlements | Soils | | $CO_2$ |
| 50 | Land - use Change and Forestry | Settlements | Land Converted to Settlements | Soils | | $CO_2$ |
| 51 | Land - use Change and Forestry | Other land | land Converted to Other land | Soils | | $CO_2$ |
| 52 | Land - use Change and Forestry | Harvested Wood Product | | | | $CO_2$ |
| 53 | Land - use Change and Forestry | Harvested Wood Product | | | | $CH_4$ |
| 54 | Land - use Change and Forestry | Harvested Wood Product | | | | $N_2O$ |
| 55 | Waste | Wastewater Handling | Domestic and Commercial Wastewater | | | $CH_4$ |
| 56 | Waste | Wastewater Handling | Domestic and Commercial Wastewater | | | $N_2O$ |
| 57 | Waste | Waste Incineration | | | | $N_2O$ |

# Annex 6. Additional Information to be Considered as Part of the NIR Submission or Other Useful Reference Information

## 6.1. 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.

### 6.1.1. 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.

### 6.1.2. 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.

### 6.1.3. 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 (Climate Change Policy Division, 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.
- Quality control (QC) of the data provided to the Ministry of the Environment and the GIO.
- (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 (the 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 is 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-gas [HFCs, PFCs, and $SF_6$], Breakout group on Agriculture, Breakout group on Waste, and Breakout group on LULUCF). The inventory WG and breakout groups comprise experts in various fields, and consider suggestions for inventory improvements. Improvement suggestions are considered once more by the Committee before approval.

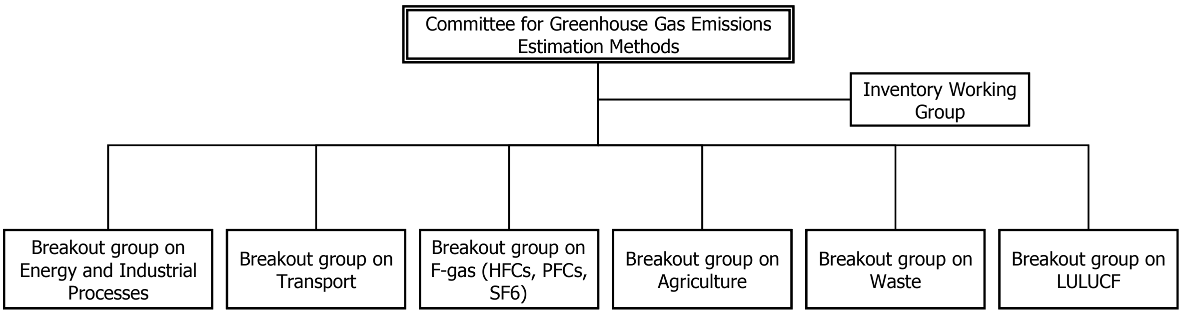



Figure 6-1 Structure of the Committee for the Greenhouse Gas Emissions Estimation Methods

### 6) GHG Inventory Quality Assurance Working Group (Expert Peer Review) (QA-WG)

The GHG Inventory Quality Assurance Working Group (the QA-WG) 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.

### 7) 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.

### 6.1.4. 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. The main relevant ministries and agencies and relevant organizations that provide data are as shown in Table 6-1

Table 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 |
| | local public entity | Carbon Content of Waste by Composition |

### 6.1.5. 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), LULUCF-GPG, and the 2006 IPCC Guidelines.

### 6.1.6. 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 QA-WG, 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 6-2 below is a diagram of the inventory improvement process.

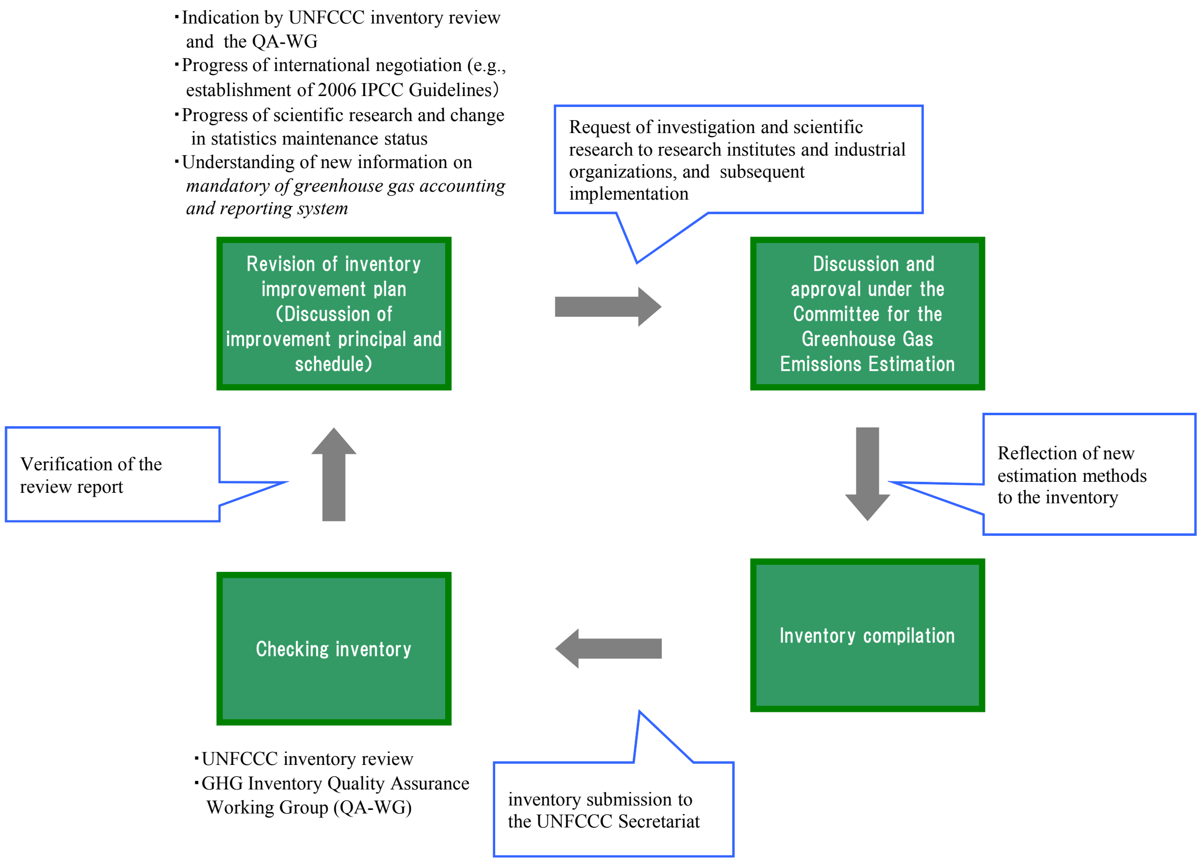



Figure 6-2 Diagram of the inventory improvement process

### 6.1.7. 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 LULUCF-GPG. 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, and relevant organizations—are considered to be QC. External reviews by experts who are outside the inventory compilation system (the QA-WG) 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 6-3 sketches Japan's QA/QC activities.

Table 6-2 Summary of Japan's QA/QC activity

| | Implementing entity | Main contents of activity |
|---|---|---|
| QC (Quality Control) | Ministry of the Environment (Climate Change Policy Division, Global Environment Bureau) | ・Progress management of the inventory compilation and overall control<br>・Check of inventory compiled by the GIO (CRF, NIR, spreadsheets, and other information)<br>・Establishment and revision of QA/QC plan<br>・Check of the inventory improvement plan<br>・Holding the meeting of the Committee for the Greenhouse Gas Emissions Estimation Methods |
| | Greenhouse Gas Inventory Office of Japan, Center for Global Environmental Research, National Institute for Environmental Studies (GIO) | ・QC check in inventory compilation<br>・Archiving of QA/QC activity records and relevant data and documents<br>・Development of information system<br>・Making of inventory improvement plan<br>・Making of revised QA/QC plan |
| | Relevant Ministry and Agencies (including the Ministry of the Environment) and relevant organizations | ・Preparation of activity data, emission factor, and other data needed for inventory compilation, and submission of the data by the submission deadline.<br>・Check of various data supplying to the GIO<br>・Check and validation of inventory compiled by the GIO (CRF, NIR, spreadsheets, and other information) |
| | Committee for the Greenhouse Gas Emissions Estimation Methods | ・Discussion and Assessment for estimation methods, emission factors, and activity data |
| | Private Consultant Companies | ・Check of inventory compiled by the GIO (CRF, NIR, spreadsheets, and other information) |
| QA (Quality Assurance) | Inventory Quality Assurance Working Group (QA-WG) (Expert Peer Review) | ・Validation of estimation methods, emission factors, and activity data<br>・Inventory assessment |

#### 6.1.7.1. QC activity

#### 6.1.7.1.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), and the QC activities conducted by the relevant ministries and agencies and the relevant organizations in part 3).

***1） Sectoral expert (SE)***

SEs perform 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 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 recalculations have been correctly performed
- Confirming time series consistency for emissions
- Confirming inventory completeness
- Confirming that CRF Reporter data are correctly transferred to CRF Excel files
- Confirming that emissions are correctly totaled

### *3） Data providers*

Relevant ministries and agencies and relevant organizations that provide activity data and other data in the inventory compilation process conduct the following QC activities from the perspectives of the completeness/representativeness, accuracy, consistency, and transparency of the data provided.

- Confirming that the provided data are correctly transcribed to input sheets
- Confirming that, in gathering and processing the data, the following QC checks are carried out among those responsible, or by using the system and other means
- Performing verification to guarantee data accuracy (such as by comparison with and verification of other, similar data)
- Evaluating data uncertainty
- (When data span multiple years), confirming that data have been prepared with methods that are consistent over the entire time span
- (When data preparation methods differ over time), documenting related information (such as reasons for changes and what has been changed)
- (When provided data are obtained by complete enumeration), confirming that all areas of concern to the study are covered
- (When provided data are obtained by sampling), confirming grounds (such as checks by experts) enabling one to judge that the representativeness of study samples is sufficiently guaranteed

- (When estimates are made in the processing of study data), confirming that QA (such as checks by experts and reviews) has been performed on the soundness of the estimation methods
- Documenting information on the above items (such as data estimation methods and signs of checks by experts)
- Documenting procedures for preparing statistics and performing studies
- Archive of related information, including the above-mentioned documents, in prescribed locations

#### 6.1.7.1.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).

### 6.1.7.2. 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.

1. GHG Inventory Quality Assurance Working Group (Expert Peer Review)
2. Internal QA

#### 6.1.7.2.a. GHG Inventory Quality Assurance Working Group (Expert Peer Review) (QA-WG)

***1） Summary***

The QA-WG 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.

#### 6.1.7.2.b. Internal QA

Internal QA consists of inventory checking by staff members who are not among the SEs responsible for each category.

The GIO has one or two SEs for each category who prepare the estimation files, CRF, and NIR, but SEs mutually assure the quality of each other’s work by checking the content of inventory categories in whose preparation they are not directly involved.

### 6.1.8. 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 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)、LULUCF-GPG

3 Private consultant companies cooperate in correspondence of the revies based on the operating agreement with the Ministry of the Environment.

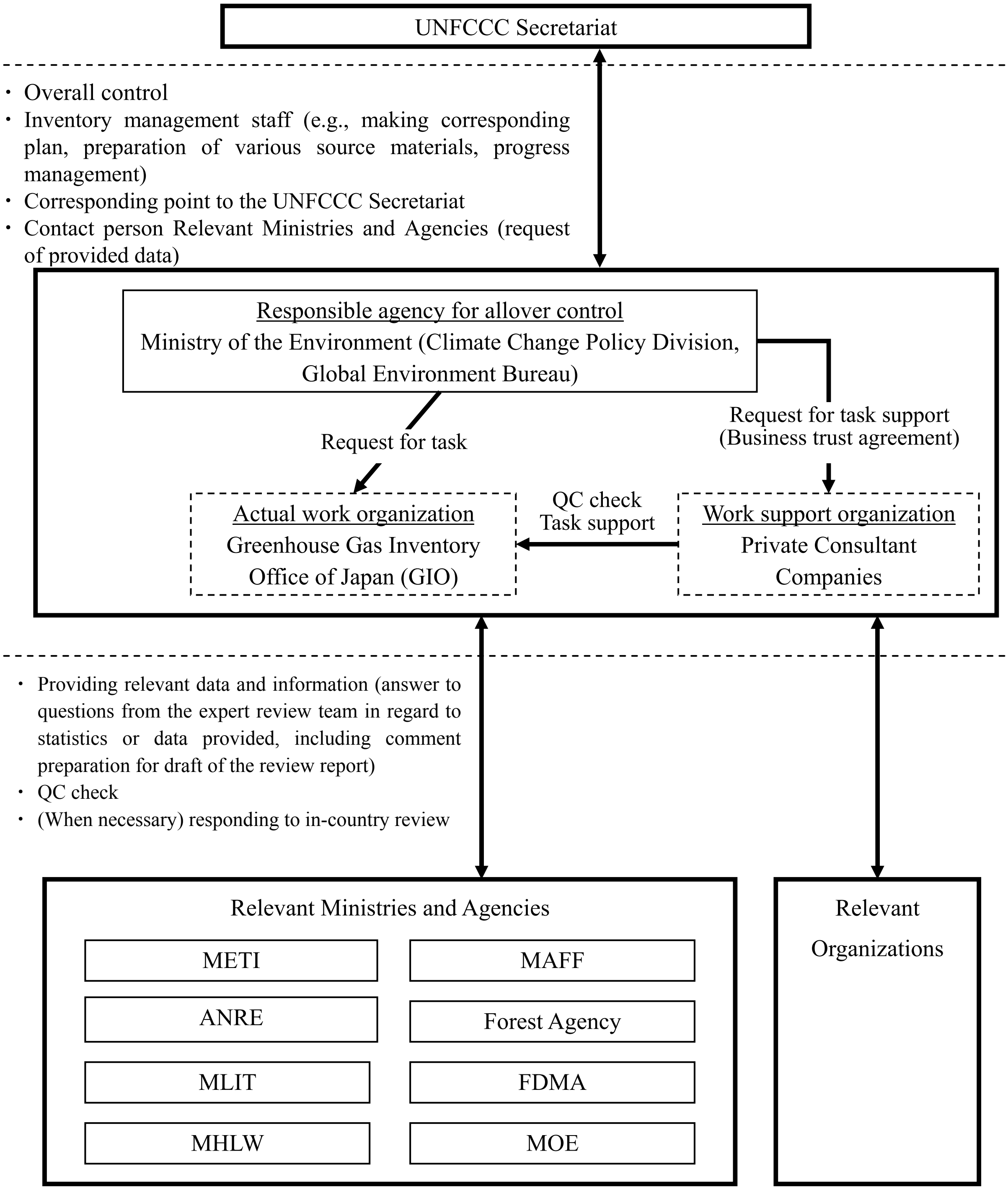



Figure 6-3 Basic structure of Japan's national system corresponding to inventory review

### 6.1.9. 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 (the GIO).

#### 6.1.9.1. 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

### 6.1.9.2. 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.
- 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.

#### 6.1.9.3. 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

## 7.1. Methodology of Uncertainty Assessment

### 7.1.1. 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 FY 2001 and again in FY 2006. Japan has annually conducted uncertainty assessment based on the Committee's results since then.

This document will be used as a guideline for conducting the uncertainty assessment of Japan's inventories. It may be subjected to be adjusted as appropriate.

### 7.1.2. Overview of Uncertainty Assessment Indicated in the Good Practice Guidance

#### 7.1.2.1. About Uncertainty Assessment

#### 7.1.2.1.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 (2000)* requires uncertainty of emissions from a source to be calculated using the method given below.

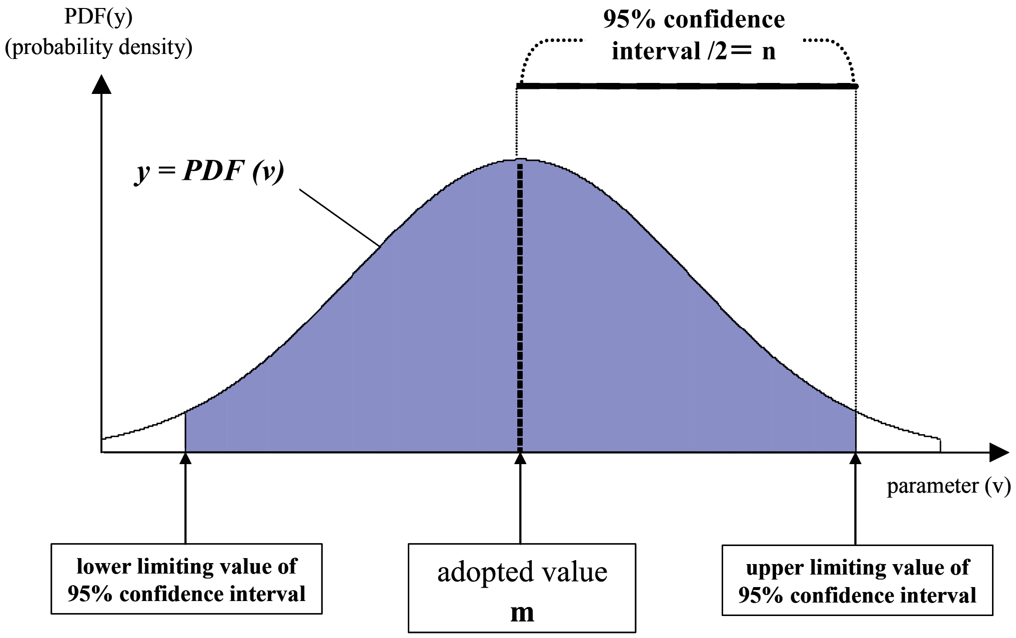
$$U = \sqrt{U_{EF}^{2} + U_{A}^{2}}$$

$U$ : Uncertainty of the emissions of the source (%)
$U_{EF}$ : Uncertainty of the emission factor (%)
$U_A$ : Uncertainty of the activity data (%)

#### 7.1.2.1.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.

$$\text{Uncertainty of EF or A} = \frac{\text{95\% confidential interval / 2 (n)}}{|\text{ Adopted Value of EF or E (m) }|}$$




### 7.1.2.1.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 (2000)* 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 (2000)*, 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 " (%)

## 7.1.2.2. Targets of the Uncertainty Assessment

The *Good Practice Guidance (2000)* 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<br>- Refers to uncertainties arising from differences in conditions at the time of measurement, such as measurements that are taken annually.<br>➢ Uncertainties associated with an establishment of emission factors<br>- 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.<br>- 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.<br>- 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.<br>➢ Uncertainties associated with an estimation of emission factors from limited measured data<br>- 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.<br>➢ Interpretation of energy balances: Production, use, and import/export data should be consistent. If not, this may give an indication of the uncertainties.<br>➢ 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.<br>➢ 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. |

| Examples of common sources of uncertainty in activity data (*Continued*) |
|---|
| ➢ Smuggling of fuel across borders: Imported fuel and the sum of sectoral fuel consumption may be compared as a crosscheck.<br>➢ Biomass fuels: Where formal markets for these fuels do not exist, consumption estimates may be much less accurate than for fuels in general.<br>➢ 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. |

#### 7.1.2.3. Methodology of Uncertainty Assessment

The *Good Practice Guidance (2000)* suggests that uncertainty is assessed through expert judgment and actual data with consideration to the sources of uncertainty indicated in section above.

### 7.1.3. Methodology of Uncertainty Assessment in Japan's Inventories

#### 7.1.3.1. 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 (2000)*, in a manner that as far as possible ensures there is no deviation from assessment standards among categories.

#### 7.1.3.2. 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 Law Concerning the Promotion of Measures to Cope with Global Warming* (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)

### 7.1.3.3. Uncertainty Assessment of Emission Factors

The uncertainty of emission factors (parameters) is assessed using the following decision tree.

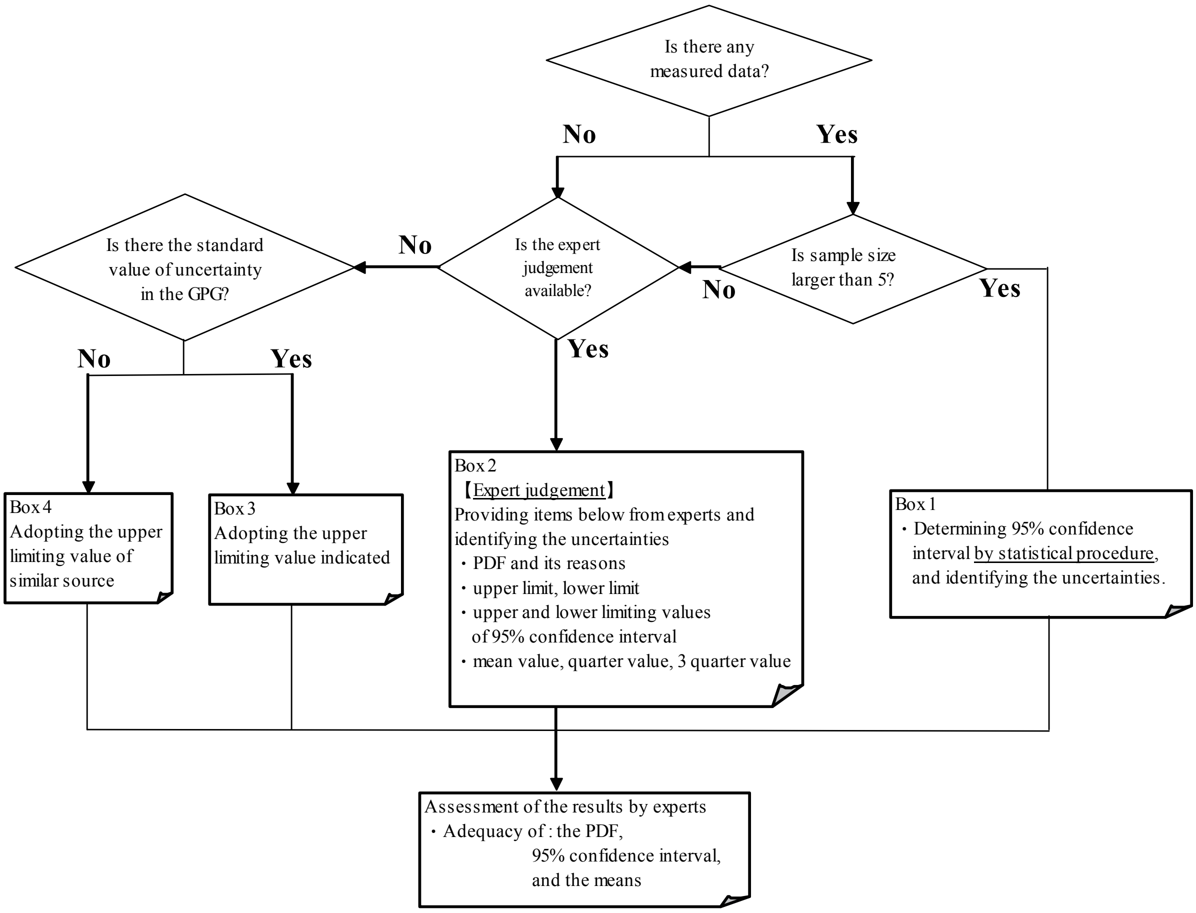



Figure 1 Decision tree for assessing uncertainty associated with emission factors established by the *Committee for the GHGs Emissions Estimation Methods*

➢ 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.

#### 7.1.3.3.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.

[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.

| Guidelines for assessment of uncertainty associated with emission factors |
|---|
| Guideline 1<br>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.<br>Guideline 2<br>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.<br>Guideline 3<br>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 $\sigma_{EF}$, and uncertainty is calculated by finding the 95 percent confidence interval in accordance with Equation 1.1.

$$Uncertainty\ of\ Emission\ Factor\ (\%) = \frac{1.96 \times \sigma_{EF}}{|\ EF\ |} \qquad \text{... Equation 1.1.}$$

$\sigma_{EF}$ : 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 $\sigma_{EF}$ 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 *wi*.

The weight applied in the weighted average, $wi$ ($\sum wi = 1$)
Sample averages : $EF = \sum ( wi \times EFi )$
Unbiased variance of sample averages :

$$\sigma_{EF}^2 = \sum \left\{ w_i \times \left( EF_i - \overline{EF} \right)^2 \right\} / \left( 1 - \sum w_i^2 \right) \times \sum w_i^2$$

***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 $\sigma_{EF}$ is calculated, to obtain the uncertainty.

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.

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 $A$.

$$EF = \frac{\sum_i EF_i \times A_i}{\sum_i A_i} = \frac{\sum_i EF_i \times A_i}{\mathrm{A}}$$

Substituting the distribution of the emission factor $EF$, $\sigma_{EF}^2$, and the distributions of the individual emission factors $EF_i$ and individual weight variables $A_i$, $\sigma_{EFi}^2$ and $\sigma_{Ai}^2$, then $\sigma_{EF}^2$ is calculated as follows, using an equation known as the Error Propagation Equation.

$$\sigma_{EF}^2 = \sum_i \left\{ \left( \frac{\partial EF}{\partial EF_i} \right)^2 \sigma_{EFi}^2 + \left( \frac{\partial EF}{\partial A_i} \right)^2 \sigma_{Ai}^2 \right\} = \sum_i \left\{ \frac{A_i^2}{A^2} \sigma_{EFi}^2 + \frac{(EF_i - EF)^2}{A^2} \sigma_{Ai}^2 \right\}$$

Thus, the uncertainty of the emission factor $U$ is obtained using the following equation.

$$U = \frac{1.96 \times \sigma_{EF}}{| EF |}$$

### 7.1.3.3.b. Case where there is no actual measurement data, or there are less than five samples

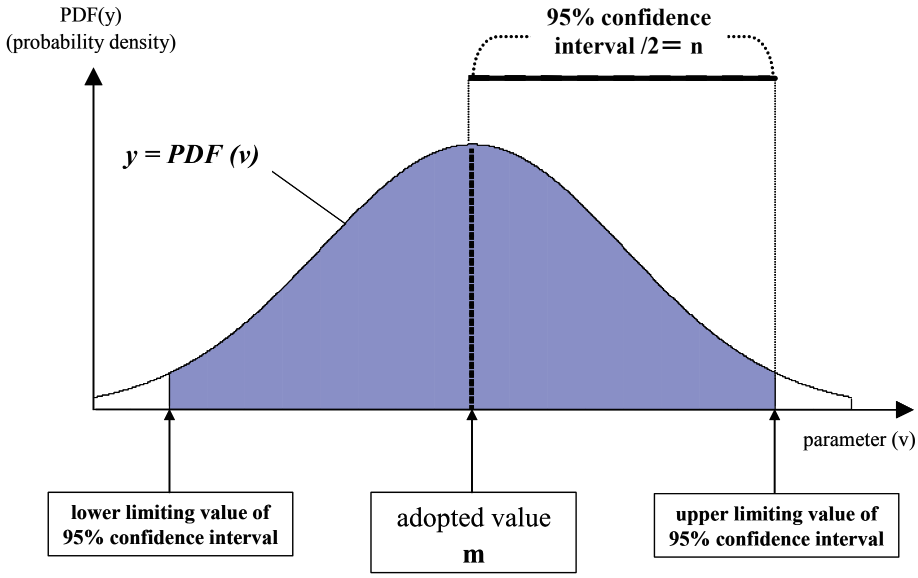
When there is no actual measurement data, or there are less than five samples, uncertainty shall be assessed by expert judgment.

***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



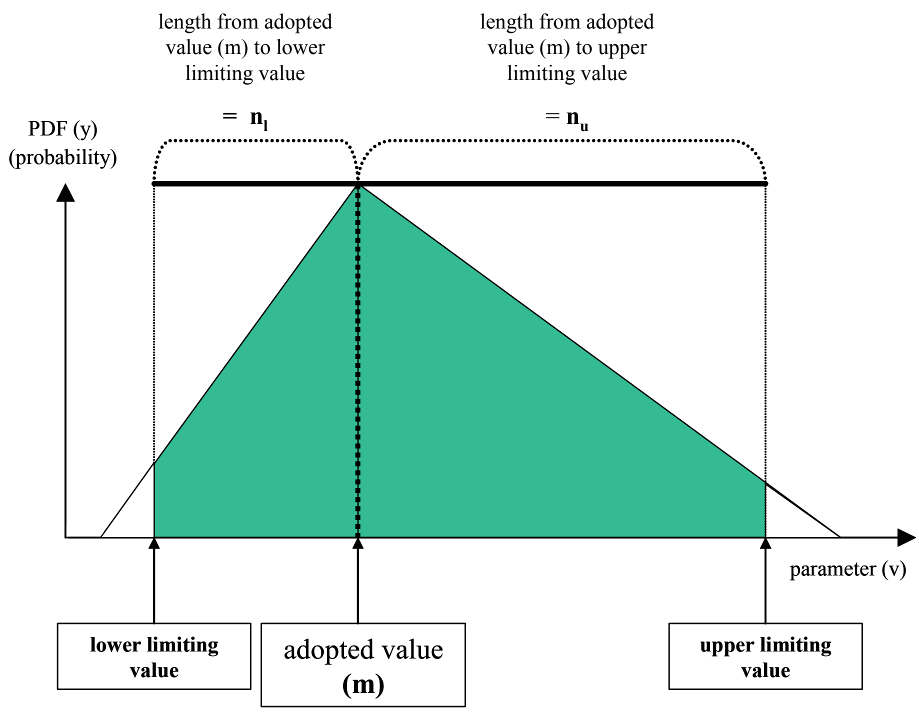

$$\text{Uncertainty of EF or A} = \frac{\text{95\% confidential interval / 2 (n)}}{|\text{ Adopted Value of EF or E (m) }|}$$

***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 (parameters), and draw a triangular distribution for the emission factors (parameters) 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 (parameter) used is larger than the upper limiting value, the emission factor should be used as the upper limiting value. If the emission factor (parameter) used is smaller than the lower limiting value, the emission factor (parameter) 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.




Uncertainty in this context is calculated using the following equation.

| |
|---|
| Uncertainty to the lower limiting value Ul (%)<br>= – {distance to lower limiting value (nl)/mode (m)}<br>Uncertainty to the upper limiting value Uu (%)<br>= + {distance to upper limiting value (n u)/mode (m)}<br>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 (2000) (Box 3)*

When the *Good Practice Guidance (2000)* 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 (2000)* should be used.

### *2） No standard value for uncertainty is provided in the Good Practice Guidance (2000) (Box 4)*

When the *Good Practice Guidance (2000)* does not provide a standard uncertainty for a particular emission source, the standard uncertainty given in the *Good Practice Guidance (2000)* for a similar emission source should be used for the upper limiting value.

| 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).

### 7.1.3.3.c. Methods for Combining Uncertainties of Emission Factors

The basic method for combining uncertainties is Tier 1 in the *Good Practice Guidance (2000)*. When a correlation between elements is strong, uncertainties may be combined using the Monte Carlo method (Tier 2 in the *Good Practice Guidance (2000)*).

### *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 on page Annex 7.5.

$$U_{EF} = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$$

$U_{EF}$ : Uncertainties of Emission Factors (%)
$U_i$ : Uncertainties of Parameter “i” (%)

### 7.1.3.4. Uncertainty Assessment of Activity Data

The uncertainty of activity data is assessed in accordance with the decision tree depicted below.

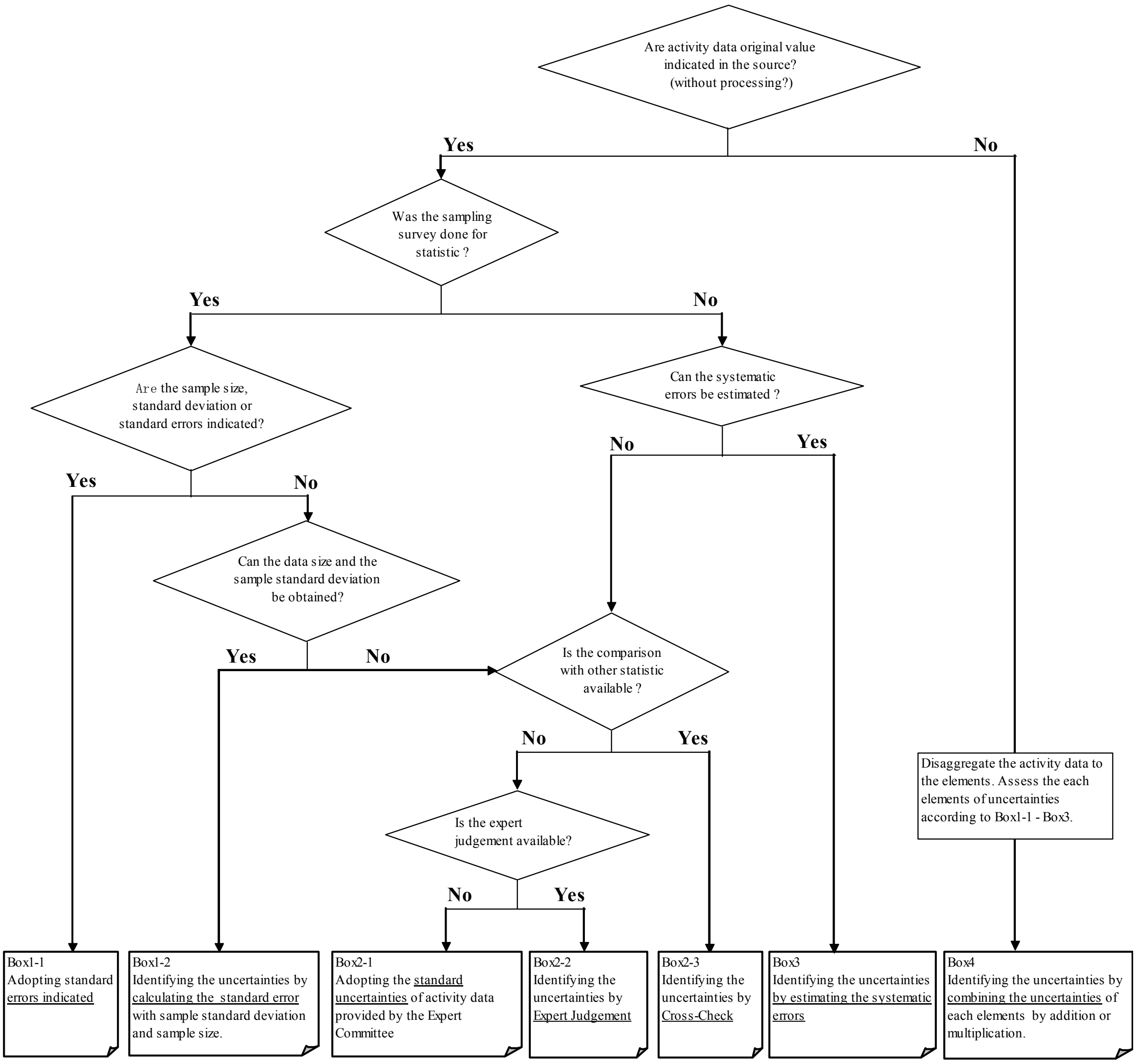



Figure 2 Decision tree for assessing uncertainty associated with activity data established by the *Committee for the GHGs Emissions Estimation Methods*

- 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.

#### 7.1.3.4.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 emission factors |
|---|
| Guideline 1<br>Only the sample error needs to be considered as part of uncertainty assessment in sample surveys.<br>Guideline 2<br>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.<br>Guideline 3<br>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.<br>Guideline 4<br>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.

$$\text{Uncertainty } U = \left(1.96 \times s / \sqrt{n}\right) / X_{ad}$$

$X_{ad}$ : 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 (2000)*.

$$Uncertainty\ U = (1.96 \times s) / X_{ap}$$

$X_{ap}$ : 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 $X_{ad}$ and the average value, by $X_{ad}$.

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 page *Annex 7.9* ) 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 (parameter) 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 2-3)**

The following standard values established by the *Committee for the GHGs Emissions Estimations Methods* will be used.

Table 1 Uncertainty of sample statistics established by the Committee for the GHGs Emissions Estimation Methods

| | Designated statistics | Other statistics |
|---|---|---|
| Sample survey | 50 [%] | 100 [%] |

The values for designated 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 (2000)* and other material. Statistics other than designated statistics have been deemed to be twice the designated 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 (2000)*.

***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)*" on the previous page.

***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 2 Uncertainty of sample statistics established by the Committee for the GHGs Emissions Estimation Methods

| | Designated statistics | Other statistics |
|---|---|---|
| Survey of total population (no rounding) | 5 [%] | 10 [%] |
| Survey of total population (rounding) | 20 [%] | 40 [%] |

The values for designated 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 designated statistics have been deemed to be twice the designated statistics.

### 7.1.3.4.b. Using statistical values processesd 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 : Carbon dioxide 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

[2] Environmental Agency, *The Estimation of $CO_2$ Emission in Japan*, 1992

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 $A_1 + A_2$

$$U_{A\text{-}total} = \frac{\sqrt{(U_{A1} \times A_1)^2 + (U_{A2} \times A_2)^2}}{A_1 + A_2}$$

$U_{An}$ : Uncertainty of element An (%)

### 7.1.3.5. Uncertainty Assessment of Emissions

### 7.1.3.5.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(2000)* 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.

$$U_{Ei} = \sqrt{U_{EFi}^2 + U_{Ai}^2}$$

$U_{Ei}$ : 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*".

### 7.1.3.5.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(2000)*.

$$U_{Total} = \frac{\sqrt{(U_1 \times E_1)^2 + (U_2 \times E_2)^2 + \cdots + (U_n \times E_n)^2}}{E_1 + E_2 + \cdots + E_n}$$

$U_{Total}$ : 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.

## 7.2. Results of Uncertainty Assessment

### 7.2.1. Assumption of Uncertainty Assessment

Uncertainty Assessment is conducted with the results of uncertainty assessment in Committee for the Greenhouse Gases Emissions Estimation Methods in FY 2006.

### 7.2.2. Uncertainty of Japan's Total Emissions

In FY 2007, total net emissions in Japan were approximately 1,293 million tons (carbon dioxide equivalents). Uncertainty of total emissions has been assessed at 1% and uncertainty introduced into the trend in total national net emissions has been assessed at 2%.

Table 3 Uncertainty of Japan's Total Net Emissions

| IPCC Category | GHGs | Emissions / Removals [Gg $CO_2$ eq.] A | [%] | Combined Uncertainty [%] 1) B | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|
| 1A. Fuel Combustion ($CO_2$) | $CO_2$ | 1,235,227.4 | 95.5% | 1% | 10 | 0.69% | 2 |
| 1A. Fuel Combustion (Stationary:$CH_4$,$N_2O$) | $CH_4$、$N_2O$ | 5,819.2 | 0.5% | 27% | 3 | 0.12% | 7 |
| 1A. Fuel Combustion (Transport:$CH_4$,$N_2O$) | $CH_4$、$N_2O$ | 2,992.5 | 0.2% | 371% | 1 | 0.86% | 1 |
| 1B. Fugitive Emissions from Fuels | $CO_2$、$CH_4$、$N_2O$ | 454.1 | 0.0% | 19% | 5 | 0.01% | 8 |
| 2. Industrial Processes ($CO_2$,$CH_4$,$N_2O$) | $CO_2$、$CH_4$、$N_2O$ | 54,723.8 | 4.2% | 7% | 7 | 0.31% | 6 |
| 2. Industrial Processes (HFCs,PFCs,$SF_6$) | HFCs、PFCs、$SF_6$ | 24,078.6 | 1.9% | 24% | 4 | 0.44% | 4 |
| 3. Solvent & other Product Use | $N_2O$ | 244.8 | 0.0% | 5% | 9 | 0.00% | 9 |
| 4. Agriculture | $CH_4$、$N_2O$ | 26,546.3 | 2.1% | 18% | 6 | 0.37% | 5 |
| 5. LULUCF | $CO_2$、$CH_4$、$N_2O$ | -81,352.6 | -6.3% | 6% | 8 | -0.37% | 10 |
| 6. Waste | $CO_2$、$CH_4$、$N_2O$ | 24,174.8 | 1.9% | 32% | 2 | 0.59% | 3 |
| Total Emissions | (D) | 1,292,908.9 | 100.0% | (E) 2) **1%** | | | |

1) $C = A \times B / D$

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

Hereafter, the same method for calculating uncertainty assessment has been used in each sector appearing in Table 4 and the following tables.

### 7.2.3. Energy Sector

#### 7.2.3.1. 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.

From FY 2007 on, "the greenhouse gas emissions from the incineration of waste used as an alternative fuel", which was previously reported in the Waste Sector (6.C., Waste Incineration), are included in this sector (1.A. Fuel Combustion).

Table 4 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 [3] | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|---|---|---|
| 1A. Fuel Combustion | Solid Fuels | Steel Making Coal | $CO_2$ | 16,496.0 | 3.5% | 1.2% | 4% | 19 | 0.05% | 15 |
| | | Steam Coal (imported) | $CO_2$ | 263,950.4 | 2.0% | 1.2% | 2% | 31 | 0.48% | 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 | $CO_2$ | 98,094.1 | 1.7% | 1.2% | 2% | 39 | 0.16% | 4 |
| | | Coal Tar | $CO_2$ | 1,831.8 | 5.0% | 1.2% | 5% | 14 | 0.01% | 28 |
| | | Coal Briquette | $CO_2$ | 0.0 | 5.0% | 1.2% | 5% | 14 | 0.00% | 38 |
| | | Coke Oven Gas | $CO_2$ | 15,433.3 | 2.0% | 1.2% | 2% | 31 | 0.03% | 21 |
| | | Blast Furnace Gas | $CO_2$ | 44,948.5 | 3.8% | 1.2% | 4% | 17 | 0.14% | 7 |
| | | Converter Furnace Gas | $CO_2$ | 11,138.9 | 2.9% | 1.2% | 3% | 20 | 0.03% | 22 |
| | Liquid Fuels | Crude Oil for Refinery | $CO_2$ | 0.0 | 0.8% | 2.3% | 2% | 26 | 0.00% | 38 |
| | | Crude Oil for Power Generation | $CO_2$ | 30,863.9 | 0.9% | 2.3% | 2% | 25 | 0.06% | 12 |
| | | Vitumous Mixture Fuel | $CO_2$ | 0.0 | 0.4% | 2.3% | 2% | 30 | 0.00% | 38 |
| | | NGL & Condensate | $CO_2$ | 67.0 | 1.6% | 2.3% | 3% | 21 | 0.00% | 36 |
| | | Naphtha | $CO_2$ | 583.2 | 0.1% | 2.3% | 2% | 34 | 0.00% | 31 |
| | | Reformed Material Oil | $CO_2$ | 0.0 | 0.1% | 2.3% | 2% | 34 | 0.00% | 38 |
| | | Gasoline | $CO_2$ | 136,841.4 | 0.03% | 2.3% | 2% | 38 | 0.24% | 2 |
| | | Jet Fuel | $CO_2$ | 14,577.3 | 1.0% | 2.3% | 3% | 24 | 0.03% | 20 |
| | | Kerosene | $CO_2$ | 54,343.6 | 0.05% | 2.3% | 2% | 37 | 0.10% | 10 |
| | | Gas Oil or Diesel Oil | $CO_2$ | 91,989.5 | 1.2% | 2.3% | 3% | 23 | 0.18% | 3 |
| | | Heating Oil A | $CO_2$ | 60,414.2 | 1.5% | 2.3% | 3% | 22 | 0.13% | 8 |
| | | Heating Oil B | $CO_2$ | 120.1 | 5.0% | 2.3% | 6% | 10 | 0.00% | 33 |
| | | Heating Oil C | $CO_2$ | 82,149.0 | 0.6% | 2.3% | 2% | 27 | 0.15% | 6 |
| | | Lubricating Oil | $CO_2$ | 206.4 | 5.0% | 2.3% | 6% | 10 | 0.00% | 32 |
| | | Asphalt | $CO_2$ | 10,783.3 | 0.6% | 2.3% | 2% | 27 | 0.02% | 24 |
| | | Non Asphalt Heavy Oil Products | $CO_2$ | 0.1 | 0.6% | 2.3% | 2% | 27 | 0.00% | 37 |
| | | Oil Coke | $CO_2$ | 11,590.3 | 5.0% | 2.3% | 6% | 10 | 0.05% | 14 |
| | | Galvanic Furnace Gas | $CO_2$ | 133.5 | 2.9% | 2.3% | 4% | 18 | 0.00% | 34 |
| | | Refinary Gas | $CO_2$ | 36,137.5 | 5.0% | 2.3% | 6% | 10 | 0.15% | 5 |
| | | LPG | $CO_2$ | 30,171.7 | 0.1% | 2.3% | 2% | 34 | 0.05% | 13 |
| | Gaseous Fuels | LNG | $CO_2$ | 120,836.9 | 0.1% | 0.3% | 0% | 42 | 0.03% | 19 |
| | | Indigenous Natural Gas | $CO_2$ | 2,317.1 | 0.6% | 0.3% | 1% | 40 | 0.00% | 30 |
| | | Town Gas* | $CO_2$ | 81,959.1 | 0.5% | 0.3% | 1% | 41 | 0.04% | 18 |
| | | Small Scale Town Gas* | $CO_2$ | 1,266.9 | 0.1% | 0.3% | 0% | 42 | 0.00% | 35 |
| | Other Fuels | Municipal Solid Waste (Plastics) | $CO_2$ | 6,660.0 | 4.3% | 16.0% | 17% | 6 | 0.09% | 11 |
| | | Municipal Solid Waste (Waste textile) | $CO_2$ | 961.4 | 4.3% | 22.4% | 23% | 5 | 0.02% | 25 |
| | | Industrial Solid Waste (Waste Oil) | $CO_2$ | 112.9 | 4.8% | 104.4% | 105% | 1 | 0.01% | 27 |
| | | Industrial Solid Waste (Plastics) | $CO_2$ | 332.1 | 4.8% | 100.0% | 100% | 3 | 0.03% | 23 |
| | | Raw material and fuel use of MSW | $CO_2$ | 446.1 | 4.3% | 16.0% | 17% | 6 | 0.01% | 29 |
| | | Raw material and fuel use of ISW (Waste Oil) | $CO_2$ | 1,329.2 | 4.8% | 104.4% | 105% | 1 | 0.11% | 9 |
| | | Raw material and fuel use of ISW (Waste Plastics) | $CO_2$ | 3,808.9 | 4.8% | 12.3% | 13% | 9 | 0.04% | 17 |
| | | Raw material and fuel use of Waste tire | $CO_2$ | 992.7 | 4.8% | 14.5% | 15% | 8 | 0.01% | 26 |
| | | Fuel use of RDF and RPF | $CO_2$ | 1,339.6 | 42.6% | 10.6% | 44% | 4 | 0.05% | 16 |
| | Sub Total | | | 1,235,227.4 | | | 1% | | 0.69% | |
| Total Emissions | | | (D) | 1,292,908.9 | | | 1% | | | |

* Reported in Gaseous Fuels according to the main material; LNG

3) $B = \sqrt{a^2 + b^2}$ (Hereafter, the same method has been used in each sector appearing in Table5 and following)

### 7.2.3.2. Stationary Combustion ($CH_4$ and $N_2O$)

Table 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 | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1A. Fuel Combustion (Stationary) | | | | $CH_4$ | 574.4 | — [4] | — [4] | 47% | 12 | 0.02% | 2 |
| | | | | $N_2O$ | 4,564.7 | — [4] | — [4] | 33% | 15 | 0.12% | 1 |
| | C. Waste Incineration | Municipal Solid Waste | | $CH_4$ | 10.8 | — | — | 101% | 7 | 0.00% | 7 |
| | | | | $N_2O$ | 510.8 | — | — | 42% | 13 | 0.02% | 3 |
| | | Industrial Solid Waste | | $CH_4$ | 0.1 | 111.5% | 100.0% | 150% | 2 | 0.00% | 15 |
| | | | | $N_2O$ | 42.8 | 58.8% | 100.0% | 116% | 4 | 0.00% | 5 |
| | | Raw material and fuel use of MSW | | $CH_4$ | 0.0 | 179.4% | 10.0% | 180% | 1 | 0.00% | 18 |
| | | | | $N_2O$ | 0.0 | 111.2% | 10.0% | 112% | 5 | 0.00% | 17 |
| | | Raw material and fuel use of ISW | Waste Oil | $CH_4$ | 3.3 | — | — | 74% | 10 | 0.00% | 10 |
| | | | | $N_2O$ | 4.3 | — | — | 41% | 14 | 0.00% | 11 |
| | | | Waste Plastics | $CH_4$ | 0.6 | 91.7% | 10.0% | 92% | 8 | 0.00% | 14 |
| | | | | $N_2O$ | 13.8 | 29.7% | 10.0% | 31% | 17 | 0.00% | 8 |
| | | | Waste Wood | $CH_4$ | 69.8 | 80.2% | 100.0% | 128% | 3 | 0.01% | 4 |
| | | | | $N_2O$ | 11.7 | 45.3% | 100.0% | 110% | 6 | 0.00% | 6 |
| | | Raw material and fuel use of Waste tir | | $CH_4$ | 0.9 | — | — | 91% | 9 | 0.00% | 13 |
| | | | | $N_2O$ | 3.4 | — | — | 26% | 18 | 0.00% | 12 |
| | | Fuel use of RDF and RPF | | $CH_4$ | 0.1 | — | — | 49% | 11 | 0.00% | 16 |
| | | | | $N_2O$ | 7.7 | — | — | 33% | 16 | 0.00% | 9 |
| | Sub Total | | | | 5,819.2 | | | 27% | | 0.12% | |
| Total Emissions | | | | (D) | 1,292,908.9 | | | 1% | | | |

4) Because "—" means aggregation of detailed sub-categories, uncertainties of EF/RF and AD can not be calculated for this level of disaggregation of categories.

### 7.2.3.3. Mobile Combustion ($CH_4$ and $N_2O$)

Table 6 Results of uncertainty assessment of mobile combustion ($CH_4$ and $N_2O$)

| IPCC Category | | GHGs | Emissions / Removals [Gg CO2eq.] A | EF/RF Uncertainty [%] a | AD Uncertainty [%] b | Combined Uncertainty [%] B | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|---|---|
| 1A.Fuel Combustion (Transport) | a. Civil Aviation | $CH_4$ | 4.8 | 200.0% | 10.0% | 200% | 4 | 0.00% | 6 |
| | | $N_2O$ | 109.1 | 10000.0% | 10.0% | 10000% | 1 | 0.84% | 1 |
| | b. Road Transportation | $CH_4$ | 179.3 | 40.0% | 50.0% | 64% | 6 | 0.01% | 4 |
| | | $N_2O$ | 2,490.0 | 50.0% | 50.0% | 71% | 5 | 0.14% | 2 |
| | c. Railways | $CH_4$ | 0.8 | — | — | 14% | 7 | 0.00% | 8 |
| | | $N_2O$ | 82.8 | — | — | 11% | 8 | 0.00% | 7 |
| | d. Navigation | $CH_4$ | 24.3 | 200.0% | 13.0% | 200% | 3 | 0.00% | 5 |
| | | $N_2O$ | 101.4 | 1000.0% | 13.0% | 1000% | 2 | 0.08% | 3 |
| | Sub Total | | 2,992.5 | | | 371% | | 0.86% | |
| Total Emissions | | (D) | 1,292,908.9 | | | 1% | | | |

(Note) $CO_2$ emissions from 1A Fuel Combustion (Transport) have been reported under the Table 4.

### 7.2.3.4. Fugitive Emissions from Fuel

Table 7 Results of uncertainty assessment of fugitive emissions from fuel

| IPCC Category | | | | | GHGs | Emissions / Removals [Gg CO2eq.] A | EF/RF Uncertainty [%] a | AD Uncertainty [%] b | Combined Uncertainty [%] B | rank | Combined uncertainty as % of total national emissions C | rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B. Fugitive Emissions from Fuels | 1. Solid Fuels | a. Coal Mining | i. Underground Mines | Mining Activities | $CH_4$ | 18.6 | — | – | 5% | 24 | 0.00% | 12 |
| | | | | Post-Mining Activities | $CH_4$ | 21.3 | 200.0% | 10.0% | 200% | 1 | 0.00% | 2 |
| | | | ii. Surface Mines | Mining Activities | $CH_4$ | 10.7 | 200.0% | 10.0% | 200% | 1 | 0.00% | 3 |
| | | | | Post-Mining Activities | $CH_4$ | 0.9 | 200.0% | 10.0% | 200% | 1 | 0.00% | 11 |
| | 2. Oil and Natural Gas | a. Oil | | i. Exploration | $CO_2$ | 0.02 | 25.0% | 10.0% | 27% | 7 | 0.00% | 20 |
| | | | | | $CH_4$ | 0.02 | 25.0% | 10.0% | 27% | 6 | 0.00% | 21 |
| | | | | | $N_2O$ | 0.00006 | 25.0% | 10.0% | 27% | 4 | 0.00% | 24 |
| | | | | ii. Production | $CO_2$ | 0.09 | 25.0% | 5.0% | 25% | 9 | 0.00% | 17 |
| | | | | | $CH_4$ | 10.2 | 25.0% | 5.0% | 25% | 9 | 0.00% | 9 |
| | | | | iii. Transport | CO2 | 0.0054 | 25.0% | 5.0% | 25% | 9 | 0.00% | 22 |
| | | | | | $CH_4$ | 1.7 | 25.0% | 5.0% | 25% | 9 | 0.00% | 14 |
| | | | | iv. Refining / Storage | $CH_4$ | 16.4 | 25.0% | 0.9% | 25% | 23 | 0.00% | 7 |
| | | b. Natural Gas | | ii. Production / Processing | $CO_2$ | 0.5 | 25.0% | 5.0% | 25% | 9 | 0.00% | 16 |
| | | | | | $CH_4$ | 285.8 | 25.0% | 5.0% | 25% | 9 | 0.01% | 1 |
| | | | | iii. Transmission | $CH_4$ | 22.8 | 25.0% | 10.0% | 27% | 4 | 0.00% | 4 |
| | | | | iv. Distribution | $CH_4$ | 15.7 | 25.0% | 8.7% | 26% | 8 | 0.00% | 6 |
| | | c. Venting and Flaring | Venting | i. oil | $CO_2$ | 0.0 | 25.0% | 5.0% | 25% | 9 | 0.00% | 23 |
| | | | | | $CH_4$ | 9.7 | 25.0% | 5.0% | 25% | 9 | 0.00% | 10 |
| | | | Flaring | i. oil | $CO_2$ | 22.4 | 25.0% | 5.0% | 25% | 9 | 0.00% | 5 |
| | | | | | $CH_4$ | 0.97 | 25.0% | 5.0% | 25% | 9 | 0.00% | 15 |
| | | | | | $N_2O$ | 0.066 | 25.0% | 5.0% | 25% | 9 | 0.00% | 18 |
| | | | | ii. Gas | $CO_2$ | 14.5 | 25.0% | 5.0% | 25% | 9 | 0.00% | 8 |
| | | | | | $CH_4$ | 1.9 | 25.0% | 5.0% | 25% | 9 | 0.00% | 13 |
| | | | | | $N_2O$ | 0.053 | 25.0% | 5.0% | 25% | 9 | 0.00% | 19 |
| | Sub Total | | | | | 454.1 | | | 19% | | 0.01% | |
| Total Emissions | | | | | (D) | 1,292,908.9 | | | 1% | | | |

## 7.2.4. Industrial Processes

### 7.2.4.1. $CO_2$, $CH_4$ 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 8 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 | | $CO_2$ | 30,076.2 | 3.0% | 10.0% | 10% | 15 | 0.24% | **1** |
| 2. Industrial Processes | A. Mineral Products | 2. Lime Production | | $CO_2$ | 7,799.3 | 15.0% | 5.0% | 16% | 14 | 0.10% | **3** |
| 2. Industrial Processes | A. Mineral Products | 3. Limestone & Dolomite Use | Limestone | $CO_2$ | 11,641.1 | 16.4% | 4.8% | 17% | 12 | 0.15% | **2** |
| 2. Industrial Processes | A. Mineral Products | 3. Limestone & Dolomite Use | Dolomite | $CO_2$ | 362.4 | 3.5% | 3.9% | 5% | 17 | 0.00% | 11 |
| 2. Industrial Processes | A. Mineral Products | 4. Soda Ash Production and Use | | $CO_2$ | 340.0 | 15.0% | 6.5% | 16% | 13 | 0.00% | 8 |
| 2. Industrial Processes | B. Chemical Industries | 1. Ammonia Production | | $CO_2$ | 2,296.0 | 22.5% | 5.0% | 23% | 11 | 0.04% | **5** |
| 2. Industrial Processes | B. Chemical Industries | Chemical Industries other than | | $CO_2$ | 1,002.8 | 77.2% | 5.0% | 77% | 8 | 0.06% | **4** |
| 2. Industrial Processes | B. Chemical Industries | 2. Nitric Acid, | | $N_2O$ | 589.3 | 46.0% | 5.0% | 46% | 10 | 0.02% | 6 |
| 2. Industrial Processes | B. Chemical Industries | 3. Adipic Acid | | $N_2O$ | 270.9 | 9.0% | 2.0% | 9% | 16 | 0.00% | 9 |
| 2. Industrial Processes | B. Chemical Industries | 4. Carbide | | $CH_4$ | 0.66 | 100.0% | 10.0% | 100% | **5** | 0.00% | 17 |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Carbon Black | $CH_4$ | 6.2 | 54.8% | 5.0% | 55% | 9 | 0.00% | 14 |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Ethylene | $CH_4$ | 2.4 | 77.2% | 5.0% | 77% | 7 | 0.00% | 16 |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Dichloroethylene | $CH_4$ | 0.37 | 100.7% | 5.0% | 101% | **4** | 0.00% | 18 |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Styrene | $CH_4$ | 2.2 | 113.2% | 5.0% | 113% | **3** | 0.00% | 15 |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Methanol | $CH_4$ | 0.0 | NA | NA | NA | NA | NA | NA |
| 2. Industrial Processes | B. Chemical Industries | 5. Other | Coke | $CH_4$ | 104.7 | 98.5% | 5.0% | 99% | 6 | 0.01% | 7 |
| 2. Industrial Processes | C. Metal Production | 1. Iron and steel | | $CO_2$ | 212.0 | – | – | 5% | 18 | 0.00% | 12 |
| 2. Industrial Processes | C. Metal Production | 1. Iron and steel | | $CH_4$ | 15.0 | 163.0% | 5.0% | 163% | **1** | 0.00% | 10 |
| 2. Industrial Processes | C. Metal Production | 2. Ferroalloy | | $CH_4$ | 2.3 | 163.0% | 5.0% | 163% | **1** | 0.00% | 13 |
| 2. Industrial Processes | Sub Total | | | | 54,723.8 | | | 7% | | 0.31% | |
| Total Emissions | | | | (D) | 1,292,908.9 | | | 1% | | | |

## 7.2.4.2. F-gas

Table 9 Results of uncertainty assessment of industrial processes (F-gas)

| 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 | 14.7 | 33.0% | 5.0% | 33% | 29 | 0.00% | 21 |
| 2. Industrial Processes (F-gas) | C. Metal Production | 4. SF6 Used in Aluminium and Magnesium Foundries | | | | $SF_6$ | 996.1 | – | 5.0% | 5% | 31 | 0.00% | 18 |
| 2. Industrial Processes (F-gas) | E. Production of F-gas | 1. By-product Emissions (HCFC-22) | | | | HFCs | 217.6 | 2.0% | 5.0% | 5% | 30 | 0.00% | 20 |
| 2. Industrial Processes (F-gas) | E. Production of F-gas | 2. Fugitive Emissions | | | | HFCs | 280.0 | 100.0% | 10.0% | 100% | **1** | 0.02% | 10 |
| 2. Industrial Processes (F-gas) | E. Production of F-gas | 2. Fugitive Emissions | | | | PFCs | 783.0 | 100.0% | 10.0% | 100% | **1** | 0.06% | 6 |
| 2. Industrial Processes (F-gas) | E. Production of F-gas | 2. Fugitive Emissions | | | | $SF_6$ | 1,270.4 | 100.0% | 10.0% | 100% | **1** | 0.10% | **4** |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Domestic Refrigerator | manufacturing | | HFCs | 366.2 | 50.0% | 40.0% | 64% | 6 | 0.02% | 13 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Domestic Refrigerator | stock | | HFCs | IE | 50.0% | 40.0% | 64% | 6 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Domestic Refrigerator | disposal | | HFCs | IE | – | 40.0% | 40% | 20 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Commercial Refrigerator | manufacturing | | HFCs | 6,881.7 | 50.0% | 40.0% | 64% | 6 | 0.34% | **1** |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Commercial Refrigerator | stock | | HFCs | IE | 50.0% | 40.0% | 64% | 6 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Commercial Refrigerator | disposal | | HFCs | IE | – | 40.0% | 40% | 20 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Stationary Air-Conditioning | manufacturing | | HFCs | 1,692.5 | 50.0% | 40.0% | 64% | 6 | 0.08% | **5** |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Stationary Air-Conditioning | stock | | HFCs | IE | 50.0% | 40.0% | 64% | 6 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Stationary Air-Conditioning | disposal | | HFCs | IE | – | 40.0% | 40% | 20 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Mobile Air-Conditioning | manufacturing | | HFCs | 2,435.1 | 50.0% | 40.0% | 64% | 6 | 0.12% | **3** |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Mobile Air-Conditioning | stock | | HFCs | IE | 50.0% | 40.0% | 64% | 6 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 1. Refrigeration and Air Conditioning Equipment | Mobile Air-Conditioning | disposal | | HFCs | IE | – | 40.0% | 40% | 20 | 0.00% | 24 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 2. Foam Blowing | | manufacturing | | HFCs | 191.8 | 50.0% | 50.0% | 71% | **4** | 0.01% | 14 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 2. Foam Blowing | | stock | | HFCs | 124.9 | 50.0% | 50.0% | 71% | **4** | 0.01% | 16 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 3. Fire Extinguisher | | manufacturing | | HFCs | 6.2 | 50.0% | 40.0% | 64% | 6 | 0.00% | 22 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 4. Aerosols / MDI | Aerosols | manufacturing | | HFCs | 34.5 | – | 40.0% | 40% | 20 | 0.00% | 19 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 4. Aerosols / MDI | Aerosols | stock | | HFCs | 618.5 | – | 40.0% | 40% | 20 | 0.02% | 11 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 4. Aerosols / MDI | MDI | manufacturing | | HFCs | 5.4 | – | 40.0% | 40% | 20 | 0.00% | 23 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 4. Aerosols / MDI | MDI | stock | | HFCs | 191.4 | – | 40.0% | 40% | 20 | 0.01% | 17 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 5. Solvents | | | | PFCs | 1,944.4 | – | 40.0% | 40% | 20 | 0.06% | 7 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 7. Semiconductor Manufacture | | | | HFCs | 164.4 | 50.0% | 40.0% | 64% | 6 | 0.01% | 15 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 7. Semiconductor Manufacture | | | | PFCs | 3,741.3 | 50.0% | 40.0% | 64% | 6 | 0.19% | **2** |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 7. Semiconductor Manufacture | | | | $SF_6$ | 1,196.0 | 50.0% | 40.0% | 64% | 6 | 0.06% | 8 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 8. Electrical Equipment | | manufacturing | | $SF_6$ | 481.6 | 30.0% | 40.0% | 50% | 19 | 0.02% | 12 |
| 2. Industrial Processes (F-gas) | F. Consumption of F-gas | 8. Electrical Equipment | | stock | | $SF_6$ | 440.8 | 50.0% | 40.0% | 64% | 6 | 0.02% | 9 |
| 2. Industrial Processes (F-gas) | Sub Total | | | | | | 24,078.6 | | | 24% | | 0.44% | |
| Total Emissions | | | | | | (D) | 1,292,908.9 | | | 1% | | | |

(Note) Uncertainty of $SF_6$ emissions from 2.C.4 Magnesium Foundries are applied same value as that of 2.C.3 Aluminium

### 7.2.5. Solvents and Other Product Use

Table 10 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 | $N_2O$ | 244.8 | — | 5.0% | 5% | 1 | 0.00% | 1 |
| | Sub Total | | | 244.8 | | | 5% | | 0.00% | |
| Total Emissions | | | (D) | 1,292,908.9 | | | 1% | | | |

### 7.2.6. Agriculture

Table 11 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 | | $CH_4$ | 3,334.6 | — | 5.0% | 15% | 63 | 0.04% | 14 |
| | | Non-Dairy Cattle | | $CH_4$ | 3,527.7 | — | 5.0% | 19% | 62 | 0.05% | 12 |
| | | Buffalo | | $CH_4$ | 0.09 | 50.0% | 100.0% | 112% | 44 | 0.00% | 57 |
| | | Sheep | | $CH_4$ | 0.84 | 50.0% | 100.0% | 112% | 44 | 0.00% | 49 |
| | | Goat | | $CH_4$ | 1.29 | 50.0% | 100.0% | 112% | 44 | 0.00% | 44 |
| | | Swine | | $CH_4$ | 224.4 | 50.0% | 0.8% | 50% | 58 | 0.01% | 19 |
| | | Horse | | $CH_4$ | 31.7 | 50.0% | 100.0% | 112% | 44 | 0.00% | 30 |
| | B. Manure Management | Dairy Cattle | | $CH_4$ | 1,938.257 | — | — | 78% | 54 | 0.12% | 5 |
| | | | | $N_2O$ | 635.201 | — | — | 91% | 52 | 0.04% | 13 |
| | | Non-Dairy Cattle | | $CH_4$ | 95.307 | — | — | 73% | 56 | 0.01% | 25 |
| | | | | $N_2O$ | 834.898 | — | — | 125% | 42 | 0.08% | 9 |
| | | Buffalo | | $CH_4$ | 0.003 | 100.0% | 100.0% | 141% | 31 | 0.00% | 63 |
| | | | | $N_2O$ | 0.014 | 100.0% | 100.0% | 141% | 31 | 0.00% | 62 |
| | | Swine | | $CH_4$ | 287.794 | — | 0.8% | 106% | 48 | 0.02% | 17 |
| | | | | $N_2O$ | 1,370.354 | — | 0.8% | 92% | 51 | 0.10% | 7 |
| | | Poultry (Hen, Broiler) | | $CH_4$ | 68.926 | — | 2.0% | 53% | 57 | 0.00% | 29 |
| | | | | $N_2O$ | 1,982.204 | — | 2.0% | 79% | 53 | 0.12% | 4 |
| | | Sheep | | $CH_4$ | 0.057 | 100.0% | 100.0% | 141% | 31 | 0.00% | 58 |
| | | | | $N_2O$ | 0.985 | 100.0% | 100.0% | 141% | 31 | 0.00% | 45 |
| | | Goat | | $CH_4$ | 0.056 | 100.0% | 100.0% | 141% | 31 | 0.00% | 59 |
| | | | | $N_2O$ | 5.568 | 100.0% | 100.0% | 141% | 31 | 0.00% | 35 |
| | | Horse | | $CH_4$ | 3.668 | 100.0% | 100.0% | 141% | 31 | 0.00% | 36 |
| | | | | $N_2O$ | 31.499 | 100.0% | 100.0% | 141% | 31 | 0.00% | 26 |
| | C. Rice Cultivation | Continuously Flooded | | $CH_4$ | 197.1 | 116.3% | 0.3% | 116% | 43 | 0.02% | 18 |
| | | Intermittently Flooded | Straw amendment | $CH_4$ | 3,717.5 | — | 0.3% | 32% | 61 | 0.09% | 8 |
| | | | Various compost | $CH_4$ | 966.5 | — | 0.3% | 32% | 60 | 0.02% | 16 |
| | | | No-amendment | $CH_4$ | 773.2 | — | 0.3% | 46% | 59 | 0.03% | 15 |
| | D. Agricultural Soils | 1. Direct Soil Emissions | Synthetic Fertilizers | $N_2O$ | 1,437.1 | — | — | 139% | 39 | 0.15% | 1 |
| | | | Animal Waste AQplied to Soils | $N_2O$ | 1,052.9 | — | — | 152% | 30 | 0.12% | 3 |
| | | | N-Fixing Crops | $N_2O$ | 83.6 | — | — | 99% | 49 | 0.01% | 23 |
| | | | Crop residues | $N_2O$ | 664.7 | — | — | 211% | 16 | 0.11% | 6 |
| | | | Organic soil | $N_2O$ | 110.2 | — | — | 712% | 1 | 0.06% | 11 |
| | | 2. Pasture, | | $N_2O$ | 12.1 | — | — | 133% | 40 | 0.00% | 32 |
| | | 3. Indirect Emissions | Atmospheric Deposition | $N_2O$ | 1,305.1 | — | — | 75% | 55 | 0.08% | 10 |
| | | | N Leaching & Run-off | $N_2O$ | 1,671.7 | — | — | 97% | 50 | 0.13% | 2 |
| | F. Field Burning of Agricultural Residue | 1. Cereals | Wheat | $CH_4$ | 5.9 | — | — | 186% | 20 | 0.00% | 34 |
| | | | | $N_2O$ | 1.4 | — | — | 185% | 24 | 0.00% | 40 |
| | | | Barley | $CH_4$ | 1.2 | — | — | 185% | 22 | 0.00% | 41 |
| | | | | $N_2O$ | 1.0 | — | — | 187% | 18 | 0.00% | 42 |
| | | | Maize | $CH_4$ | 22.7 | 418.0% | 50.0% | 421% | 7 | 0.01% | 22 |
| | | | | $N_2O$ | 19.3 | 423.0% | 50.0% | 426% | 3 | 0.01% | 24 |
| | | | Oats | $CH_4$ | 0.6 | — | — | 156% | 28 | 0.00% | 50 |
| | | | | $N_2O$ | 0.5 | — | — | 170% | 27 | 0.00% | 51 |
| | | | Rye | $CH_4$ | 0.030 | — | — | 130% | 41 | 0.00% | 60 |
| | | | | $N_2O$ | 0.015 | — | — | 154% | 29 | 0.00% | 61 |
| | | | Rice | $CH_4$ | 54.0 | 178.0% | 50.0% | 185% | 23 | 0.01% | 21 |
| | | | | $N_2O$ | 21.6 | 175.0% | 50.0% | 182% | 26 | 0.00% | 28 |
| | | 2. Pulse | Peas | $CH_4$ | 0.20 | 481.0% | 20.0% | 481% | 2 | 0.00% | 47 |
| | | | | $N_2O$ | 0.17 | 423.0% | 20.0% | 423% | 5 | 0.00% | 52 |
| | | | Soybeans | $CH_4$ | 2.54 | 176.0% | 50.0% | 183% | 25 | 0.00% | 37 |
| | | | | $N_2O$ | 0.89 | 182.0% | 50.0% | 189% | 17 | 0.00% | 43 |
| | | | Other (Adzuki beans) | $CH_4$ | 0.70 | 179.0% | 50.0% | 186% | 21 | 0.00% | 46 |
| | | | | $N_2O$ | 0.32 | 180.0% | 50.0% | 187% | 19 | 0.00% | 53 |
| | | | Other (kidney beans) | $CH_4$ | 0.23 | 418.0% | 50.0% | 421% | 7 | 0.00% | 48 |
| | | | | $N_2O$ | 0.09 | 418.0% | 50.0% | 421% | 7 | 0.00% | 55 |
| | | | Other (peanuts) | $CH_4$ | 0.09 | 418.0% | 50.0% | 421% | 7 | 0.00% | 54 |
| | | | | $N_2O$ | 0.04 | 418.0% | 50.0% | 421% | 7 | 0.00% | 56 |
| | | 3. Tuber & Roots | Potatoes | $CH_4$ | 3.6 | 418.0% | 20.0% | 418% | 15 | 0.00% | 33 |
| | | | | $N_2O$ | 5.0 | 419.0% | 20.0% | 419% | 14 | 0.00% | 31 |
| | | | Other: Sugarbeet | $CH_4$ | 0.9 | 417.0% | 50.0% | 420% | 13 | 0.00% | 39 |
| | | | | $N_2O$ | 1.0 | 419.0% | 50.0% | 422% | 6 | 0.00% | 38 |
| | | 4. Sugar Cane | | $CH_4$ | 10.3 | 418.0% | 50.0% | 421% | 7 | 0.00% | 27 |
| | | | | $N_2O$ | 25.1 | 423.0% | 50.0% | 426% | 3 | 0.01% | 20 |
| | Sub Total | | | | 26,546.3 | | | 18% | | 0.37% | |
| Total Emissions | | | | (D) | 1,292,908.9 | | | 1% | | | |

### 7.2.7. LULUCF

Table 12 Results of uncertainty assessment of LULUCF

| 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 5) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | A | a | b | B | | C | |
| 5. LULUCF | A. Forest Land | 1. Forest Land remaining Forest Land | $CO_2$ | -81,595.5 | – | – | 6% | 12 | -0.36% | **1** |
| | | 2. Land converted to Forest Land | $CO_2$ | -1,271.6 | – | – | 6% | 11 | -0.01% | 7 |
| | | | $CH_4$ | 1.9 | 25.0% | 47.1% | 53% | **4** | 0.00% | 11 |
| | | | $N_2O$ | 0.2 | 75.6% | 47.1% | 89% | **1** | 0.00% | 12 |
| | B. Cropland | 1. Cropland remaining Cropland | $CO_2$ | IE,NA,NE | – | – | – | — | — | — |
| | | 2. Land converted to Cropland | $CO_2$ | 265.4 | – | – | 17% | 9 | 0.00% | 8 |
| | | | $CH_4$ | NE,NO | – | – | – | — | — | — |
| | | | $N_2O$ | 7.9 | – | – | 76% | **3** | 0.00% | 10 |
| | C. Grassland | 1. Grassland remaining Grassland | $CO_2$ | IE,NA,NE | – | – | – | — | — | — |
| | | 2. Land converted to Grassland | $CO_2$ | -614.9 | – | – | 19% | 8 | -0.01% | 6 |
| | | | $CH_4$ | NE,NO | – | – | – | — | — | — |
| | | | $N_2O$ | NE,NO | – | – | – | — | — | — |
| | D. Wetlands | 1. Wetlands remaining Wetlands | $CO_2$ | NA,NE,NO | – | – | – | — | — | — |
| | | 2. Land converted to Wetlands | $CO_2$ | 167.1 | – | – | 21% | 7 | 0.00% | 9 |
| | | | $CH_4$ | NE,NO | – | – | – | — | — | — |
| | | | $N_2O$ | NE,NO | – | – | – | — | — | — |
| | E. Settlements | 1. Settlements remaining Settlements | $CO_2$ | -677.6 | – | – | 82% | **2** | -0.04% | **2** |
| | | 2. Land converted to Settlements | $CO_2$ | 1,526.4 | – | – | 15% | 10 | 0.02% | **3** |
| | | | $CH_4$ | NE,NO | – | – | – | — | — | — |
| | | | $N_2O$ | NE,NO | – | – | – | — | — | — |
| | F. Other Land | 1. Other Land remaining Other Land | $CO_2$ | — | – | – | – | — | — | — |
| | | 2. Land converted to Other Land | $CO_2$ | 607.7 | – | – | 30% | 6 | 0.01% | **4** |
| | | | $CH_4$ | NE,NO | – | – | – | — | — | — |
| | | | $N_2O$ | NE,NO | – | – | – | — | — | — |
| | G. Other | $CO_2$ emissions from agricultural lime application | $CO_2$ | 230.3 | -50.0% | 10.0% | 51% | **5** | 0.01% | **5** |
| | Sub Total | | | -81,352.6 | | | 6% | | 0.37% | |
| Total Emissions | | | (D) | 1,292,908.9 | | | 1% | | | |

5) Numbers of the rank have been assessed based on the absolute values of "Combined uncertainty as % of total national emissions".

### 7.2.8. Waste

From FY 2007 on, "the greenhouse gas emissions from the incineration of waste used as an alternative fuel", which was previously reported in this sector (6.C., Waste Incineration), are included in the Energy Sector (1.A. Fuel Combustion).

Table 13 Results of uncertainty assessment of Waste

| 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 | |
| 6. Waste | A. Solid Waste Disposal on Land | 1. Managed Waste Disposal on Land | Kitchen Garbage | $CH_4$ | 554.52 | 42.4% | 32.4% | 53% | 29 | 0.02% | 13 |
| | | | Waste PAQer | $CH_4$ | 1,564.13 | 42.4% | 42.7% | 60% | 26 | 0.07% | 6 |
| | | | Waste Textile | $CH_4$ | 100.74 | 43.8% | 42.9% | 61% | 25 | 0.00% | 22 |
| | | | Waste Wood | $CH_4$ | 965.12 | 42.5% | 56.6% | 71% | 21 | 0.05% | 7 |
| | | | Sewage Sludge | $CH_4$ | 286.86 | 44.2% | 32.0% | 55% | 28 | 0.01% | 16 |
| | | | Human Waste Sludge | $CH_4$ | 96.44 | 44.2% | 32.6% | 55% | 27 | 0.00% | 24 |
| | | | Water Purification Sludge | $CH_4$ | 48.58 | 108.6% | 31.7% | 113% | 8 | 0.00% | 23 |
| | | | Organic Sludge from Manufacture | $CH_4$ | 281.16 | 54.0% | 33.4% | 63% | 24 | 0.01% | 15 |
| | | | Livestock Waste | $CH_4$ | 580.41 | 46.9% | 49.4% | 68% | 23 | 0.03% | 10 |
| | | 3. Other | Illegal Disposal | $CH_4$ | 45.00 | 42.5% | 66.8% | 79% | 16 | 0.00% | 26 |
| | B. Wastewater Handling | 1. Industrial Wastewater | | $CH_4$ | 103.45 | 60.0% | 37.4% | 71% | 22 | 0.01% | 21 |
| | | | | $N_2O$ | 118.90 | 300.0% | 51.1% | 304% | 1 | 0.03% | 12 |
| | | 2. Domestic and Commercial Wastewater | Sewage Treatment Plant | $CH_4$ | 250.22 | 30.9% | 10.4% | 33% | 31 | 0.01% | 20 |
| | | | | $N_2O$ | 678.08 | 145.7% | 10.4% | 146% | 5 | 0.08% | 5 |
| | | | Private Sewerage Tank | $CH_4$ | 434.62 | 86.8% | 10.0% | 87% | 14 | 0.03% | 11 |
| | | | | $N_2O$ | 300.45 | 71.0% | 10.0% | 72% | 20 | 0.02% | 14 |
| | | | Human-Waste Treatment Plant | $CH_4$ | 19.06 | 100.0% | 12.3% | 101% | 11 | 0.00% | 28 |
| | | | | $N_2O$ | 6.36 | 100.0% | 33.9% | 106% | 9 | 0.00% | 31 |
| | | | Degradation of domestic wastewater in nature | $CH_4$ | 561.86 | — | — | 76% | 17 | 0.03% | 9 |
| | | | | $N_2O$ | 55.21 | — | — | 76% | 17 | 0.00% | 25 |
| | C. Waste Incineration | Municipal Solid Waste | Plastics | $CO_2$ | 3,154.48 | 4.3% | 16.0% | 17% | 34 | 0.04% | 8 |
| | | | Waste textile | $CO_2$ | 455.37 | 4.3% | 22.4% | 23% | 33 | 0.01% | 18 |
| | | | | $CH_4$ | 5.13 | — | — | 101% | 12 | 0.00% | 33 |
| | | | | $N_2O$ | 241.96 | — | — | 42% | 30 | 0.01% | 19 |
| | | Industrial Solid Waste | Waste Oil | $CO_2$ | 4,440.66 | 4.8% | 104.4% | 105% | 10 | 0.36% | 1 |
| | | | Plastics | $CO_2$ | 4,284.60 | 4.8% | 100.0% | 100% | 13 | 0.33% | 2 |
| | | | | $CH_4$ | 4.42 | 111.5% | 100.0% | 150% | 4 | 0.00% | 32 |
| | | | | $N_2O$ | 2,041.38 | 58.8% | 100.0% | 116% | 7 | 0.18% | 4 |
| | | Specially Contorolled Industrial Solid Waste | | $CO_2$ | 1,891.52 | — | — | 167% | 2 | 0.24% | 3 |
| | | | | $CH_4$ | 0.26 | — | — | 142% | 6 | 0.00% | 34 |
| | | | | $N_2O$ | 12.75 | — | — | 159% | 3 | 0.00% | 27 |
| | D. Oher | Decomposition of petroleum-derived surface-active agent | | $CO_2$ | 559.8 | — | — | 25% | 32 | 0.01% | 17 |
| | | Composting of Organic Waste | | $CH_4$ | 16.6 | — | — | 74% | 19 | 0.00% | 30 |
| | | | | $N_2O$ | 14.7 | — | — | 86% | 15 | 0.00% | 29 |
| | Sub Total | | | | 24,174.8 | | | 32% | | 0.59% | |
| Total Emissions | | | | (D) | 1,292,908.9 | | | 1% | | | |

6) Regarding 6A1, uncertainty of “Anaerobic landfill”, which is the largest source under this sub-category, has been used.

7) Regarding 6A2, uncertainty of “Gappei-shori johkasou”, which is the largest source under this sub-category, has been used.

8) Regarding $CH_4$ of 6C MSW, uncertainty of “Semi-Continuous Incinerator” has been used.

9) Regarding $CH_4$ of 6C ISW, uncertainty of “Waste Paper and Waste Wood” has been used.

10) Regarding $N_2O$ of 6C ISW, uncertainty of “Waste Plastics” has been used.

11) Regarding 6C Fuel use of RDF and RPF, uncertainty of “RDF” has been used.

### 7.2.9. Consideration of the results

The result of uncertainty assessment shows that Japan’s uncertainty of national total emissions is approximately 1%. This value is relatively smaller compared to 21.3% of UK indicated in the *Good Practice Guidance (2000).* 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 14 Sensitivity Analysis on $N_2O$ emissions from "4.D. Agricultural Soils 1 Direct Emissions"

| | $N_2O$ Emissions [Gg $CO_2$eq.] | Uncertainty of EF | Uncertainty of Total Emissions | Note |
|---|---|---|---|---|
| Original | 3,597.58 | 129.9% | 2.4% | 2001's Emissions contained in the GHG inventory submitted in 2003 |
| Case 1 | 3,597.58 | 500% | 2.6% | EF uncertainty was changed to UK's case |
| Case 2 | 71,951.53 | 129.9% | 4.8% | Emissions were changed to be approximately 5% of national total emissions in 2001 |

### 7.2.10. 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.)

### 7.2.11. Reference Material

Results of uncertainty assessment in this year using Table 6.1 in *GPG (2000)* are indicated below.

**Table 6.1**
**Tier1 Uncertainty Calculation & Reporting**

| IPCC Source Category | | | | | B | C | D | E | F | G | H | | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Gas | Base year emissions / removals | 2007 emissions / removals | Activity Data Uncertainty | EForRF Uncertainty | Combined Uncertainty | Combined Uncertainty as % of Total National Emissions in 2007 | | Type A Sensitivity | Type B Sensitivity | Uncertainty in trend in National Emissions introduced by EForRF | Uncertainty in trend in National Emissions introduced by Activity | 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 | H^2 | Note B | D/ΣC | I*F Note C | J*E*√2 | (K^2+L^2)^1/2 |
| | | | | | | Gg $CO_2$ equivalent | Gg $CO_2$ equivalent | % | % | % | % | | % | % | % | % | % |
| 合計 | | | | | | 1,185,568.38 | 1,292,908.90 | | | | 1% | 0.0% | | | | | 2% |
| 1A.燃料の燃焼 | 固体燃料 | 原料炭 | | | $CO_2$ | 9,244.05 | 16,495.95 | 1.2% | 3.5% | 4% | 0.0% | 0.0% | 0.5% | 1.4% | 0.0% | 0.0% | 0.0% |
| | | 一般炭（輸入炭） | | | $CO_2$ | 88,401.29 | 263,950.40 | 1.2% | 2.0% | 2% | 0.5% | 0.0% | 14.1% | 22.3% | 0.3% | 0.4% | 0.5% |
| | | 一般炭（国内炭） | | | $CO_2$ | 20,125.86 | 0.00 | 1.2% | 2.0% | 2% | 0.0% | 0.0% | -1.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 無煙炭 | | | $CO_2$ | 0.00 | 0.00 | 1.2% | 4.5% | 5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | コークス | | | $CO_2$ | 117,790.21 | 98,094.13 | 1.2% | 1.7% | 2% | 0.2% | 0.0% | -2.6% | 8.3% | 0.0% | 0.1% | 0.1% |
| | | コールタール | | | $CO_2$ | 3,173.39 | 1,831.80 | 1.2% | 5.0% | 5% | 0.0% | 0.0% | -0.1% | 0.2% | 0.0% | 0.0% | 0.0% |
| | | 練豆炭 | | | $CO_2$ | 310.20 | 0.00 | 1.2% | 5.0% | 5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | コークス炉ガス | | | $CO_2$ | 15,976.84 | 15,433.27 | 1.2% | 2.0% | 2% | 0.0% | 0.0% | -0.2% | 1.3% | 0.0% | 0.0% | 0.0% |
| | | 高炉ガス | | | $CO_2$ | 43,496.15 | 44,948.53 | 1.2% | 3.8% | 4% | 0.1% | 0.0% | -0.2% | 3.8% | 0.0% | 0.1% | 0.1% |
| | | 転炉ガス | | | $CO_2$ | 9,303.92 | 11,138.94 | 1.2% | 2.9% | 3% | 0.0% | 0.0% | 0.1% | 0.9% | 0.0% | 0.0% | 0.0% |
| | 液体燃料 | 精製用原油 | | | $CO_2$ | 1.91 | 0.00 | 2.3% | 0.8% | 2% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 発電用原油 | | | $CO_2$ | 58,483.38 | 30,863.88 | 2.3% | 0.9% | 2% | 0.1% | 0.0% | -2.8% | 2.6% | 0.0% | 0.1% | 0.1% |
| | | 瀝青質混合物 | | | $CO_2$ | 0.00 | 0.00 | 2.3% | 0.4% | 2% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | NGL･コンデンセート | | | $CO_2$ | 1,380.12 | 67.00 | 2.3% | 1.6% | 3% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 純ナフサ | | | $CO_2$ | 1,297.82 | 583.15 | 2.3% | 0.1% | 2% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 改質生成油 | | | $CO_2$ | 0.00 | 0.00 | 2.3% | 0.1% | 2% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | ガソリン | | | $CO_2$ | 103,913.39 | 136,841.38 | 2.3% | 0.0% | 2% | 0.2% | 0.0% | 2.0% | 11.5% | 0.0% | 0.4% | 0.4% |
| | | ジェット燃料油 | | | $CO_2$ | 9,140.23 | 14,577.26 | 2.3% | 1.0% | 3% | 0.0% | 0.0% | 0.4% | 1.2% | 0.0% | 0.0% | 0.0% |
| | | 灯油 | | | $CO_2$ | 64,049.60 | 54,343.61 | 2.3% | 0.1% | 2% | 0.1% | 0.0% | -1.3% | 4.6% | 0.0% | 0.1% | 0.1% |
| | | 軽油 | | | $CO_2$ | 98,847.94 | 91,989.45 | 2.3% | 1.2% | 3% | 0.2% | 0.0% | -1.3% | 7.8% | 0.0% | 0.3% | 0.3% |
| | | Ａ重油 | | | $CO_2$ | 74,790.57 | 60,414.19 | 2.3% | 1.5% | 3% | 0.1% | 0.0% | -1.8% | 5.1% | 0.0% | 0.2% | 0.2% |
| | | Ｂ重油 | | | $CO_2$ | 1,865.42 | 120.11 | 2.3% | 5.0% | 6% | 0.0% | 0.0% | -0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | Ｃ重油 | | | $CO_2$ | 143,715.21 | 82,148.99 | 2.3% | 0.6% | 2% | 0.2% | 0.0% | -6.3% | 6.9% | 0.0% | 0.2% | 0.2% |
| | | 潤滑油 | | | $CO_2$ | 67.74 | 206.35 | 2.3% | 5.0% | 6% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | アスファルト | | | $CO_2$ | 5,510.07 | 10,783.32 | 2.3% | 0.6% | 2% | 0.0% | 0.0% | 0.4% | 0.9% | 0.0% | 0.0% | 0.0% |
| | | 他重質油・ﾊﾟﾗﾌｨﾝ等製品 | | | $CO_2$ | 7.76 | 0.11 | 2.3% | 0.6% | 2% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | オイルコークス | | | $CO_2$ | 9,505.00 | 11,590.27 | 2.3% | 5.0% | 6% | 0.0% | 0.0% | 0.1% | 1.0% | 0.0% | 0.0% | 0.0% |
| | | 電気炉ガス | | | $CO_2$ | 146.60 | 133.52 | 2.3% | 2.9% | 4% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 製油所ガス | | | $CO_2$ | 27,354.02 | 36,137.47 | 2.3% | 5.0% | 6% | 0.2% | 0.0% | 0.5% | 3.0% | 0.0% | 0.1% | 0.1% |
| | | LPG | | | $CO_2$ | 37,373.48 | 30,171.70 | 2.3% | 0.1% | 2% | 0.1% | 0.0% | -0.9% | 2.5% | 0.0% | 0.1% | 0.1% |
| | 気体燃料 | LNG | | | $CO_2$ | 76,303.80 | 120,836.86 | 0.3% | 0.1% | 0% | 0.0% | 0.0% | 3.2% | 10.2% | 0.0% | 0.0% | 0.0% |
| | | 国産天然ガス | | | $CO_2$ | 2,225.86 | 2,317.10 | 0.3% | 0.6% | 1% | 0.0% | 0.0% | 0.0% | 0.2% | 0.0% | 0.0% | 0.0% |
| | | 都市ガス（一般ガス）* | | | $CO_2$ | 34,211.10 | 81,959.07 | 0.3% | 0.5% | 1% | 0.0% | 0.0% | 3.8% | 6.9% | 0.0% | 0.0% | 0.0% |
| | | 都市ガス（簡易ガス）* | | | $CO_2$ | 1,130.79 | 1,266.89 | 0.3% | 0.1% | 0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | その他の燃料 | 一般廃棄物（プラスチック） | | | $CO_2$ | 5,616.97 | 6,659.98 | 16.0% | 4.3% | 17% | 0.1% | 0.0% | 0.0% | 0.6% | 0.0% | 0.1% | 0.1% |
| | | 一般廃棄物（繊維くず） | | | $CO_2$ | 584.61 | 961.42 | 22.4% | 4.3% | 23% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物（廃油） | | | $CO_2$ | 21.29 | 112.86 | 104.4% | 4.8% | 105% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物（廃プラスチック類） | | | $CO_2$ | 30.87 | 332.07 | 100.0% | 4.8% | 100% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 一般廃棄物の原燃料利用 | | | $CO_2$ | 0.00 | 446.08 | 16.0% | 4.3% | 17% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物の原燃料利用（廃プラスチック類） | | | $CO_2$ | 0.00 | 1,329.15 | 104.4% | 4.8% | 105% | 0.1% | 0.0% | 0.1% | 0.1% | 0.0% | 0.2% | 0.2% |
| | | 産業廃棄物の原燃料利用（廃油） | | | $CO_2$ | 2,072.74 | 3,808.86 | 12.3% | 4.8% | 13% | 0.0% | 0.0% | 0.1% | 0.3% | 0.0% | 0.1% | 0.1% |
| | | 廃タイヤの原燃料利用 | | | $CO_2$ | 524.23 | 992.71 | 14.5% | 4.8% | 15% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | ごみ固形燃料（RDF･RPF）の燃料利用 | | | $CO_2$ | 24.58 | 1,339.57 | 10.6% | 42.6% | 44% | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | 0.0% | 0.1% |
| 1A.燃料の燃焼（固定発生源） | | | | | $CH_4$ | 584.25 | 574.39 | 10.0% | 45.9% | 47% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 2,719.29 | 4,564.73 | 10.0% | 31.4% | 33% | 0.1% | 0.0% | 0.1% | 0.4% | 0.0% | 0.1% | 0.1% |
| | その他の燃料 | 一般廃棄物（プラスチック） | | | $CH_4$ | 11.33 | 10.83 | 10.0% | 100.2% | 101% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 一般廃棄物（繊維くず） | | | $N_2O$ | 369.25 | 510.84 | 10.0% | 40.6% | 42% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物（廃油） | | | $CH_4$ | 0.03 | 0.14 | 100.0% | 111.5% | 150% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物（廃プラスチック類） | | | $N_2O$ | 4.93 | 42.83 | 100.0% | 58.8% | 116% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 一般廃棄物の原燃料利用 | | | $CH_4$ | 0.00 | 0.00 | 10.0% | 179.4% | 180% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.00 | 0.01 | 10.0% | 111.2% | 112% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物の原燃料利用 | 廃プラスチック類 | | $CH_4$ | 0.00 | 3.28 | 10.0% | 72.8% | 74% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.00 | 4.25 | 10.0% | 39.6% | 41% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 廃油 | | $CH_4$ | 0.25 | 0.58 | 10.0% | 91.7% | 92% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 4.90 | 13.79 | 10.0% | 29.7% | 31% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 木くず | | $CH_4$ | 38.52 | 69.79 | 100.0% | 80.2% | 128% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 6.44 | 11.67 | 100.0% | 45.3% | 110% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 廃タイヤの原燃料利用 | | | $CH_4$ | 0.65 | 0.88 | 10.0% | 90.8% | 91% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 1.55 | 3.35 | 10.0% | 23.7% | 26% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | ごみ固形燃料（RDF･RPF）の燃料利用 | | | $CH_4$ | 0.00 | 0.13 | 10.0% | 48.1% | 49% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.16 | 7.67 | 10.0% | 30.9% | 33% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1A.燃料の燃焼（運輸） | a.航空機 | | | | $CH_4$ | 2.94 | 4.84 | 10.0% | 200.0% | 200% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 69.75 | 109.11 | 10.0% | 10000.0% | 10000% | 0.8% | 0.0% | 0.0% | 0.0% | 0.3% | 0.0% | 0.3% |
| | b.自動車 | | | | $CH_4$ | 266.66 | 179.32 | 50.0% | 40.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 3,901.71 | 2,490.03 | 50.0% | 50.0% | 71% | 0.1% | 0.0% | -0.1% | 0.2% | -0.1% | 0.1% | 0.2% |
| | c.鉄道 | | | | $CH_4$ | 1.18 | 0.80 | — | — | 14% | 0.0% | 0.0% | 0.0% | 0.0% | — | — | — |
| | | | | | $N_2O$ | 121.38 | 82.77 | — | — | 11% | 0.0% | 0.0% | 0.0% | 0.0% | — | — | — |
| | d.船舶 | | | | $CH_4$ | 26.33 | 24.26 | 13.0% | 200.0% | 200% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 111.31 | 101.42 | 13.0% | 1000.0% | 1000% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 1B.燃料からの漏出 | 1 固体燃料 | a石炭採掘 | i 坑内堀 | 採掘時 | $CH_4$ | 2,551.70 | 18.56 | 5.4% | 0.0% | 5% | 0.0% | 0.0% | -0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 採掘後工程 | $CH_4$ | 233.53 | 21.26 | 10.0% | 200.0% | 200% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | ii 露天堀 | 採掘時 | $CH_4$ | 19.50 | 10.72 | 10.0% | 200.0% | 200% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 採掘後工程 | $CH_4$ | 1.70 | 0.93 | 10.0% | 200.0% | 200% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | 2 石油及び天然ガス | a石油 | | i 試掘 | $CO_2$ | 0.03 | 0.02 | 10.0% | 25.0% | 27% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 0.03 | 0.02 | 10.0% | 25.0% | 27% | 0.0% | 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% | 0.0% |
| | | | | ii 生産 | $CO_2$ | 0.11 | 0.09 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 12.80 | 10.18 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | iii 輸送 | $CO_2$ | 0.00 | 0.01 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 0.76 | 1.66 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | iv 精製/貯蔵 | $CH_4$ | 14.73 | 16.36 | 0.9% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | b天然ガス | | i 生産／処理 | $CO_2$ | 0.25 | 0.46 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 159.12 | 285.75 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | ii 輸送 | $CH_4$ | 15.12 | 22.77 | 10.0% | 25.0% | 27% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 供給 | $CH_4$ | 13.69 | 15.70 | 8.7% | 25.0% | 26% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | c 通気弁とﾌﾚｱﾘﾝｸﾞ | 通気弁 | i 油田 | $CO_2$ | 0.01 | 0.00 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 12.19 | 9.70 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | ﾌﾚｱﾘﾝｸﾞ | i 油田 | $CO_2$ | 28.17 | 22.41 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 1.22 | 0.97 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.08 | 0.07 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | ii ガス | $CO_2$ | 8.06 | 14.54 | 5.0% | 25.0% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 1.04 | 1.88 | 5.0% | 25.0% | 25% | 0.0% | 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% | 0.0% |

Table 6.1
Tier1 Uncertainty Calculation & Reporting

| | | | | | B | C | D | E | F | G | H | | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IPCC Source Category | | | | | Gas | Base year emissions / removals | 2007 emissions / removals | Activity Data Uncertainty | EForRF Uncertainty | Combined Uncertainty | Combined Uncertainty as % of Total National Emissions in 2007 | | Type A Sensitivity | Type B Sensitivity | Uncertainty in trend in National Emissions introduced by EForRF | Uncertainty in trend in National Emissions introduced by Activity | 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 | H^2 | Note B | D/ΣC | I*F Note C | J*E*√2 | (K^2+L^2)^1/2 |
| | | | | | | Gg $CO_2$ equivalent | Gg $CO_2$ equivalent | % | % | % | % | | % | % | % | % | % |
| 合計 | | | | | | 1,185,568.38 | 1,292,908.90 | | | | 1% | 0.0% | | | | | 2% |
| 2 工プロセス | A.鉱物製品 | 1.セメント | | | $CO_2$ | 37,966.28 | 30,076.22 | 10.0% | 3.0% | 10% | 0.2% | 0.0% | -1.0% | 2.5% | 0.0% | 0.4% | 0.4% |
| | | 2.生石灰 | | | $CO_2$ | 7,321.64 | 7,799.26 | 5.0% | 15.0% | 16% | 0.1% | 0.0% | 0.0% | 0.7% | 0.0% | 0.0% | 0.0% |
| | | 3.石灰石及び | 石灰石 | | $CO_2$ | 10,657.49 | 11,641.09 | 4.8% | 16.4% | 17% | 0.2% | 0.0% | 0.0% | 1.0% | 0.0% | 0.1% | 0.1% |
| | | ドロマイトの使用 | ドロマイト | | $CO_2$ | 869.92 | 362.41 | 3.9% | 3.5% | 5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 4.ソーダ灰の生産及び使用 | | | $CO_2$ | 583.63 | 339.98 | 6.5% | 15.0% | 16% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | B.化学産業 | 1.アンモニア | | | $CO_2$ | 3,384.68 | 2,296.03 | 5.0% | 22.5% | 23% | 0.0% | 0.0% | -0.1% | 0.2% | 0.0% | 0.0% | 0.0% |
| | | アンモニア以外の化学産業 | | | $CO_2$ | 1,129.29 | 1,002.83 | 5.0% | 77.2% | 77% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | 2.硝酸 | | | $N_2O$ | 765.70 | 589.27 | 5.0% | 46.0% | 46% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 3.アジピン酸 | | | $N_2O$ | 7,501.25 | 270.91 | 2.0% | 9.0% | 9% | 0.0% | 0.0% | -0.7% | 0.0% | -0.1% | 0.0% | 0.1% |
| | | 4. カーバイド | | | $CH_4$ | 0.42 | 0.66 | 10.0% | 100.0% | 100% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 5.その他 | カーボンブラック | | $CH_4$ | 5.83 | 6.18 | 5.0% | 54.8% | 55% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | エチレン | | $CH_4$ | 1.88 | 2.38 | 5.0% | 77.2% | 77% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 二塩化エチレン | | $CH_4$ | 0.28 | 0.37 | 5.0% | 100.7% | 101% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | スチレン | | $CH_4$ | 1.45 | 2.22 | 5.0% | 113.2% | 113% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | メタノール | | $CH_4$ | 3.52 | 0.00 | 5.0% | 113.2% | 113% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | コークス | | $CH_4$ | 324.84 | 104.70 | 5.0% | 98.5% | 99% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | C.金属製品 | 1.鉄鋼 | | | $CO_2$ | 356.09 | 212.02 | 4.5% | 0.0% | 5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $CH_4$ | 15.47 | 14.97 | 5.0% | 163.0% | 163% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2. フェロアロイ | | | $CH_4$ | 3.89 | 2.33 | 5.0% | 163.0% | 163% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 2 工業プロセス（HFC等F） | C.金属製品 | 3.アルミニウム | | | PFCs | 69.74 | 14.69 | 5.0% | 33.0% | 33% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 4. マグネシウム等の鋳造 | | | $SF_6$ | 119.50 | 996.13 | 5.0% | 0.0% | 5% | 0.0% | 0.0% | 0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| | E.ﾊﾛｶｰﾎﾞﾝ及びSF6の生産 | 1.副生物 | HCFC-22の製造 | | HFCs | 16,965.00 | 217.62 | 5.0% | 2.0% | 5% | 0.0% | 0.0% | -1.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2.漏出 | | | HFCs | 480.12 | 279.99 | 10.0% | 100.0% | 100% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | PFCs | 762.85 | 783.02 | 10.0% | 100.0% | 100% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | | | $SF_6$ | 4,708.30 | 1,270.43 | 10.0% | 100.0% | 100% | 0.1% | 0.0% | -0.3% | 0.1% | -0.3% | 0.0% | 0.3% |
| | F.ﾊﾛｶｰﾎﾞﾝ及びSF6の消費 | 1.冷蔵庫及び空調機器 | 家庭用冷蔵(凍)庫 | 製造・使用開始時 | HFCs | 11.34 | 366.21 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 使用時 | HFCs | 0.00 | 0.00 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 廃棄時 | HFCs | 0.00 | 0.00 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 業務用冷蔵(凍)庫 | 製造・使用開始 | HFCs | 42.48 | 6,881.70 | 40.0% | 50.0% | 64% | 0.3% | 0.0% | 0.6% | 0.6% | 0.3% | 0.3% | 0.4% |
| | | | | 使用時 | HFCs | 0.00 | 0.00 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 廃棄時 | HFCs | 0.00 | 0.00 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | ｴｱｰｺﾝﾃﾞｨｼｮﾅｰ | 製造・使用開始時 | HFCs | 0.00 | 1,692.52 | 40.0% | 50.0% | 64% | 0.1% | 0.0% | 0.1% | 0.1% | 0.1% | 0.1% | 0.1% |
| | | | | 使用時 | HFCs | 0.00 | 0.00 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 廃棄時 | HFCs | 0.00 | 0.00 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | カーエアコン等（輸送機器） | 製造時 | HFCs | 786.58 | 2,435.06 | 40.0% | 50.0% | 64% | 0.1% | 0.0% | 0.1% | 0.2% | 0.1% | 0.1% | 0.1% |
| | | | | 使用時 | HFCs | 0.00 | 0.00 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 廃棄時 | HFCs | 0.00 | 0.00 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2.発泡 | | 製造時 | HFCs | 451.76 | 191.75 | 50.0% | 50.0% | 71% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 使用時 | HFCs | 0.00 | 124.89 | 50.0% | 50.0% | 71% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 3. 消火剤 | | 製造時 | HFCs | 0.00 | 6.24 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | 4.エアゾール/噴霧器（MDI） | エアゾール | 製造時 | HFCs | 0.00 | 34.49 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 使用時 | HFCs | 1,365.00 | 618.52 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | -0.1% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | MDI | 製造時 | HFCs | 0.00 | 5.35 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | 使用時 | HFCs | 0.00 | 191.39 | 40.0% | 0.0% | 40% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 5.溶剤 | | 溶剤・洗浄剤 | PFCs | 10,382.05 | 1,944.38 | 40.0% | 0.0% | 40% | 0.1% | 0.0% | -0.8% | 0.2% | 0.0% | 0.1% | 0.1% |
| | | 7.半導体製造 | | | HFCs | 158.30 | 164.41 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | PFCs | 3,148.83 | 3,741.32 | 40.0% | 50.0% | 64% | 0.2% | 0.0% | 0.0% | 0.3% | 0.0% | 0.2% | 0.2% |
| | | | | | $SF_6$ | 1,128.98 | 1,196.04 | 40.0% | 50.0% | 64% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.1% | 0.1% |
| | | 8.電気機器 | | 製造等 | $SF_6$ | 9,560.00 | 481.61 | 40.0% | 30.0% | 50% | 0.0% | 0.0% | -0.8% | 0.0% | -0.3% | 0.0% | 0.3% |
| | | | | 使用時 | $SF_6$ | 1,444.99 | 440.80 | 40.0% | 50.0% | 64% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | 0.1% |
| 3.溶剤等 | D.その他 | 麻酔 | | | $N_2O$ | 287.07 | 244.76 | 5.0% | 0.0% | 5% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 4.農業 | A.消化管内発酵 | 乳用牛 | | | $CH_4$ | 4,042.45 | 3,334.58 | 5.0% | 14.2% | 15% | 0.0% | 0.0% | -0.1% | 0.3% | 0.0% | 0.0% | 0.0% |
| | | 肉用牛 | | | $CH_4$ | 3,322.55 | 3,527.65 | 5.0% | 18.0% | 19% | 0.1% | 0.0% | 0.0% | 0.3% | 0.0% | 0.0% | 0.0% |
| | | 水牛 | | | $CH_4$ | 0.25 | 0.09 | 100.0% | 50.0% | 112% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | めん羊 | | | $CH_4$ | 1.88 | 0.84 | 100.0% | 50.0% | 112% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 山羊 | | | $CH_4$ | 2.22 | 1.29 | 100.0% | 50.0% | 112% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 豚 | | | $CH_4$ | 261.74 | 224.40 | 0.8% | 50.0% | 50% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 馬 | | | $CH_4$ | 43.37 | 31.74 | 100.0% | 50.0% | 112% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | B.家畜排せつ物の管理 | 乳用牛 | | | $CH_4$ | 2,587.79 | 1,938.26 | 10.0% | 77.0% | 78% | 0.1% | 0.0% | -0.1% | 0.2% | -0.1% | 0.0% | 0.1% |
| | | | | | $N_2O$ | 840.93 | 635.20 | 10.0% | 90.1% | 91% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | 肉用牛 | | | $CH_4$ | 93.66 | 95.31 | 10.0% | 71.8% | 73% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 833.63 | 834.90 | 10.0% | 125.1% | 125% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | 水牛 | | | $CH_4$ | 0.01 | 0.00 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.04 | 0.01 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 豚 | | | $CH_4$ | 336.90 | 287.79 | 0.8% | 106.1% | 106% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 1,603.23 | 1,370.35 | 0.8% | 91.6% | 92% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | 家禽類（採卵鶏・ブロイラー） | | | $CH_4$ | 81.12 | 68.93 | 2.0% | 53.4% | 53% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 2,328.79 | 1,982.20 | 2.0% | 79.4% | 79% | 0.1% | 0.0% | 0.0% | 0.2% | 0.0% | 0.0% | 0.0% |
| | | めん羊 | | | $CH_4$ | 0.13 | 0.06 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 2.20 | 0.99 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 山羊 | | | $CH_4$ | 0.10 | 0.06 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 9.54 | 5.57 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 馬 | | | $CH_4$ | 5.01 | 3.67 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 43.04 | 31.50 | 100.0% | 100.0% | 141% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | C.稲作 | 常時湛水田 | | | $CH_4$ | 244.13 | 197.12 | 0.3% | 116.3% | 116% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 間断灌漑水田［中干し］ | わら施用 | | $CH_4$ | 4,604.13 | 3,717.51 | 0.3% | 31.7% | 32% | 0.1% | 0.0% | -0.1% | 0.3% | 0.0% | 0.0% | 0.0% |
| | | | 各種堆肥施用 | | $CH_4$ | 1,196.96 | 966.46 | 0.3% | 31.9% | 32% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | 無施用 | | $CH_4$ | 957.56 | 773.17 | 0.3% | 46.3% | 46% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | D.農耕地土壌 | 1. 直接排出 | 合成肥料 | | $N_2O$ | 1,909.22 | 1,437.13 | 10.0% | 138.3% | 139% | 0.2% | 0.0% | -0.1% | 0.1% | -0.1% | 0.0% | 0.1% |
| | | | 畜産廃棄物の施用 | | $N_2O$ | 1,343.23 | 1,052.94 | 10.0% | 151.3% | 152% | 0.1% | 0.0% | 0.0% | 0.1% | -0.1% | 0.0% | 0.1% |
| | | | 窒素固定作物 | | $N_2O$ | 97.18 | 83.55 | 10.0% | 98.0% | 99% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 作物残渣 | | $N_2O$ | 779.16 | 664.69 | 10.0% | 210.6% | 211% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | 有機性土壌の耕起 | | $N_2O$ | 120.68 | 110.17 | 10.0% | 711.6% | 712% | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2. 牧草地・放牧場・小放牧地の排せつ物 | | | $N_2O$ | 11.91 | 12.12 | 10.0% | 132.5% | 133% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 3. 間接排出 | 大気沈降 | | $N_2O$ | 1,555.28 | 1,305.05 | 10.0% | 74.5% | 75% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | 窒素溶脱・流出 | | $N_2O$ | 2,113.98 | 1,671.74 | 10.0% | 96.4% | 97% | 0.1% | 0.0% | -0.1% | 0.1% | -0.1% | 0.0% | 0.1% |
| | F.農業廃棄物の野焼き | 1. 穀物 | 小麦 | | $CH_4$ | 6.08 | 5.94 | 10.0% | 186.0% | 186% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 1.38 | 1.35 | 10.0% | 184.3% | 185% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 大麦 | | $CH_4$ | 1.96 | 1.15 | 10.0% | 185.2% | 185% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 1.79 | 1.00 | 10.0% | 186.8% | 187% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | とうもろこし | | $CH_4$ | 33.03 | 22.74 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 28.02 | 19.29 | 50.0% | 423.0% | 426% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | オート麦 | | $CH_4$ | 0.26 | 0.58 | 10.0% | 155.7% | 156% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.18 | 0.50 | 10.0% | 169.2% | 170% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | ライ麦 | | $CH_4$ | 0.03 | 0.03 | 10.0% | 129.5% | 130% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.01 | 0.02 | 10.0% | 153.8% | 154% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 稲 | | $CH_4$ | 62.81 | 53.99 | 50.0% | 178.0% | 185% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 25.10 | 21.58 | 50.0% | 175.0% | 182% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2. 豆類 | えんどう豆 | | $CH_4$ | 0.42 | 0.20 | 20.0% | 481.0% | 481% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.36 | 0.17 | 20.0% | 423.0% | 423% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 大豆 | | $CH_4$ | 2.44 | 2.54 | 50.0% | 176.0% | 183% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.86 | 0.89 | 50.0% | 182.0% | 189% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | その他(小豆) | | $CH_4$ | 1.11 | 0.70 | 50.0% | 179.0% | 186% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.50 | 0.32 | 50.0% | 180.0% | 187% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | その他(インゲン豆) | | $CH_4$ | 0.40 | 0.23 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.16 | 0.09 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | その他(らっかせい) | | $CH_4$ | 0.17 | 0.09 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.07 | 0.04 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 3. 根菜類 | ばれいしょ | | $CH_4$ | 4.58 | 3.57 | 20.0% | 418.0% | 418% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 6.39 | 4.98 | 20.0% | 419.0% | 419% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | その他（てんさい） | | $CH_4$ | 0.81 | 0.85 | 50.0% | 417.0% | 420% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 0.92 | 0.98 | 50.0% | 419.0% | 422% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 4. さとうきび | | | $CH_4$ | 15.69 | 10.31 | 50.0% | 418.0% | 421% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | | $N_2O$ | 38.18 | 25.08 | 50.0% | 423.0% | 426% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

**Table 6.1**
**Tier1 Uncertainty Calculation & Reporting**

| IPCC Source Category | | | | B | C | D | E | F | G | H | | I | J | K | L | M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Gas | Base year emissions / removals | 2007 emissions / removals | Activity Data Uncertainty | EForRF Uncertainty | Combined Uncertainty | Combined Uncertainty as % of Total National Emissions in 2007 | | Type A Sensitivity | Type B Sensitivity | Uncertainty in trend in National Emissions introduced by EForRF | Uncertainty in trend in National Emissions introduced by Activity | 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 | H^2 | Note B | D/ΣC | I*F Note C | J*E*√2 | (K^2+L^2)^1/2 |
| | | | | | Gg $CO_2$ equivalent | Gg $CO_2$ equivalent | % | % | % | % | | % | % | % | % | % |
| 合計 | | | | | 1,185,568.38 | 1,292,908.90 | | | | 1% | 0.0% | | | | | 2% |
| 5 土地利用・土地利用変化及び林業 | A. 森林 | 1. 転用のない森林 | | $CO_2$ | -75,127.14 | -81,595.45 | 5.0% | 2.8% | 6% | -0.4% | 0.0% | 0.0% | -6.9% | 0.0% | -0.5% | 0.5% |
| | | 2. 他の土地利用から転用された森林 | | $CO_2$ | -5,650.70 | -1,271.57 | 5.0% | 3.5% | 6% | 0.0% | 0.0% | 0.4% | -0.1% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | 8.31 | 1.91 | 47.1% | 25.0% | 53% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 0.84 | 0.19 | 47.1% | 75.6% | 89% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | B. 農地 | 1. 転用のない農地 | | $CO_2$ | IE,NA,NE | IE,NA,NE | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | 2. 他の土地利用から転用された農地 | | $CO_2$ | 2,057.84 | 265.44 | 10.0% | 14.3% | 17% | 0.0% | 0.0% | -0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | | | $N_2O$ | 68.27 | 7.86 | 10.0% | 75.1% | 76% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | C. 草地 | 1. 転用のない草地 | | $CO_2$ | IE,NA,NE | IE,NA,NE | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | 2. 他の土地利用から転用された草地 | | $CO_2$ | -516.21 | -614.90 | 10.0% | 15.6% | 19% | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | | | $N_2O$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | D. 湿地 | 1. 転用のない湿地 | | $CO_2$ | NA,NE,NO | NA,NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | 2. 他の土地利用から転用された湿地 | | $CO_2$ | 292.33 | 167.06 | 10.0% | 18.7% | 21% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | | | $N_2O$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | E. 開発地 | 1. 転用のない開発地 | | $CO_2$ | -475.77 | -677.60 | 10.0% | 81.6% | 82% | 0.0% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% |
| | | 2. 他の土地利用から転用された開発地 | | $CO_2$ | 3,548.45 | 1,526.38 | 10.0% | 10.7% | 15% | 0.0% | 0.0% | -0.2% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | | | $N_2O$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | F. その他の土地 | 1. 転用のないその他の土地 | | $CO_2$ | － | － | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | 2. 他の土地利用から転用された　その他の土地 | | $CO_2$ | 956.66 | 607.70 | 10.0% | 27.9% | 30% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | | | | $N_2O$ | NE,NO | NE,NO | － | － | － | 0.0% | 0.0% | NA | NA | NA | NA | NA |
| | G. その他の土地 | 農地土壌への石灰施用に伴う$CO_2$排出 | | $CO_2$ | 550.22 | 230.34 | 10.0% | -50.0% | 51% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 6 廃棄物 | A.固形廃棄物の陸上における処分 | 1. 管理埋立地 | 食物くず | $CH_4$ | 1,320.61 | 554.52 | 32.4% | 42.4% | 53% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 紙くず | $CH_4$ | 3,060.53 | 1,564.13 | 42.7% | 42.4% | 60% | 0.1% | 0.0% | -0.1% | 0.1% | -0.1% | 0.1% | 0.1% |
| | | | 繊維くず | $CH_4$ | 198.78 | 100.74 | 42.9% | 43.8% | 61% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 木くず | $CH_4$ | 966.07 | 965.12 | 56.6% | 42.5% | 71% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.1% | 0.1% |
| | | | 下水汚泥 | $CH_4$ | 747.43 | 286.86 | 32.0% | 44.2% | 55% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | し尿処理汚泥 | $CH_4$ | 260.93 | 96.44 | 32.6% | 44.2% | 55% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 浄水汚泥 | $CH_4$ | 90.83 | 48.58 | 31.7% | 108.6% | 113% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 製造業有機性汚泥 | $CH_4$ | 1,017.00 | 281.16 | 33.4% | 54.0% | 63% | 0.0% | 0.0% | -0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 家畜ふん尿 | $CH_4$ | 633.63 | 580.41 | 49.4% | 46.9% | 68% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 3.その他 | 不法処分 | $CH_4$ | 4.36 | 45.00 | 66.8% | 42.5% | 79% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | B.排水の処理 | 1. 産業排水の処理に伴う排出 | | $CH_4$ | 112.52 | 103.45 | 37.4% | 60.0% | 71% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 122.21 | 118.90 | 51.1% | 300.0% | 304% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 2. 生活･商業排水の処理に伴う排出 | 終末処理場 | $CH_4$ | 181.48 | 250.22 | 10.4% | 30.9% | 33% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 491.78 | 678.08 | 10.4% | 145.7% | 146% | 0.1% | 0.0% | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |
| | | | 生活排水処理施設（主に浄化槽） | $CH_4$ | 451.84 | 434.62 | 10.0% | 86.8% | 87% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 468.72 | 300.45 | 10.0% | 71.0% | 72% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | し尿処理施設 | $CH_4$ | 110.14 | 19.06 | 12.3% | 100.0% | 101% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 69.56 | 6.36 | 33.9% | 100.0% | 106% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | 生活排水の自然界における分解 | $CH_4$ | 1,264.60 | 561.86 | 10.0% | 75.4% | 76% | 0.0% | 0.0% | -0.1% | 0.0% | -0.1% | 0.0% | 0.1% |
| | | | | $N_2O$ | 137.38 | 55.21 | 10.0% | 75.4% | 76% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | C.廃棄物の焼却 | 一般廃棄物 | プラスチック | $CO_2$ | 4,834.64 | 3,154.48 | 16.0% | 4.3% | 17% | 0.0% | 0.0% | -0.2% | 0.3% | 0.0% | 0.1% | 0.1% |
| | | | 繊維くず | $CO_2$ | 503.19 | 455.37 | 22.4% | 4.3% | 23% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $CH_4$ | 9.75 | 5.13 | 10.0% | 100.2% | 101% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 317.82 | 241.96 | 10.0% | 40.6% | 42% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 産業廃棄物 | 廃油 | $CO_2$ | 3,768.87 | 4,440.66 | 104.4% | 4.8% | 105% | 0.4% | 0.0% | 0.0% | 0.4% | 0.0% | 0.6% | 0.6% |
| | | | 廃プラスチック類 | $CO_2$ | 2,120.24 | 4,284.60 | 100.0% | 4.8% | 100% | 0.3% | 0.0% | 0.2% | 0.4% | 0.0% | 0.5% | 0.5% |
| | | | | $CH_4$ | 3.59 | 4.42 | 100.0% | 111.5% | 150% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 1,193.97 | 2,041.38 | 100.0% | 58.8% | 116% | 0.2% | 0.0% | 0.1% | 0.2% | 0.0% | 0.2% | 0.2% |
| | | 特別管理産業廃棄物 | | $CO_2$ | 946.78 | 1,891.52 | 100.0% | 133.1% | 167% | 0.2% | 0.0% | 0.1% | 0.2% | 0.1% | 0.2% | 0.2% |
| | | | | $CH_4$ | 0.12 | 0.26 | 100.0% | 100.3% | 142% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 5.95 | 12.75 | 100.0% | 123.2% | 159% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | D.その他 | 石油由来の界面活性剤の分解 | | $CO_2$ | 702.83 | 559.75 | 10.0% | 22.4% | 25% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | 有機性廃棄物のコンポスト化 | | $CH_4$ | 14.48 | 16.64 | 10.0% | 73.3% | 74% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | | | | $N_2O$ | 12.83 | 14.74 | 10.0% | 85.7% | 86% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

# 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 1 Explanation of each MS Excel file

| category | file name | contents |
|---|---|---|
| | JPN-2009-1990-v1.1.xls ～ JPN-2009-2007-v1.1.xls | Common reporting format provided by UNFCCC secretariat |
| 1. Energy | 1A-nonCO2-1990-2009.xls ～ 1A-nonCO2-2007-2009.xls | Non-$CO_2$ emissions from stationary facilities |
| | 1A-CO2-1990-2009.xls ～ 1A-CO2-2007-2009.xls | $CO_2$ emissions from fuel combustions at stationary facilities |
| | 1A-MAP-2009.xls | Emissions of Non-$CO_2$ from stationary combustion |
| | 1A-MAPEF-2009.xls | Emission Factors of Non-CO2 from stationary combustion |
| | 1A-MAP-AD-1989-2009.xls ～ 1A-MAP-AD-1999-2009.xls | Share by furnace type for calculation of emissions of Non-CO2 from stationary combustion |
| | 1A-MAP-IEF-1989-2009.xls ～ 1A-MAP-IEF-1999-2009.xls | Implied Emission Factors of Non-CO2 from stationary combustion |
| | 1A-N2Ofb-2009.xls | $N_2O$ Emissions from fluidized-bed boilers |
| | 1A-residential-2009.xls | Emissions of Non-$CO_2$ from Residential Sector |
| | 1A-small-2009.xls | Emissions of Non-$CO_2$ from Commercial and other sector |
| | 1A3-2009.xls | GHGs emissions from Mobile Combustion (transport sector) (except Non-$CO_2$ from Car) |
| | 1A3-AD-2009.xls | Activity Data of Mobile Combustion (transport sector) |
| | 1A3-car-2009.xls | Non-$CO_2$ emissions from Road Transportation (car) |
| | 1A3-EF-2009.xls | Emission Factors of Mobile Combustion (transport sector) |
| | 1B-AD-2009.xls | Activity Data of Fugitive Emissions from Fuels |
| | 1B-EF-2009.xls | Emission Factors of Fugitive Emissions from Fuels |
| | 1B1-2009.xls | GHGs fugitive emissions from coal production |
| | 1B2-2009.xls | GHGs fugitive emissions from oil & gas production |
| | 1B2-NMVOC-2009.xls | NMVOC fugitive emissions from oil facilities |
| 2. Industrial Processes | 2-AD-2009.xls | Activity Data of Caotegory2 (except F-gas) |
| | 2-CH4-2009.xls | $CH_4$ emissions from Category2 (Industrial Processes) |
| | 2-CO2-2009.xls | $CO_2$ emissions from Category2 (Industrial Processes) |
| | 2-EF-2009.xls | Emission Factors of Category2 |
| | 2-Fgas-A-2009.xls | F-gas (HFCs, PFCs, $SF_6$) actual emissions |
| | 2-Fgas-P-2009.xls | F-gas (HFCs, PFCs, $SF_6$) potential emissions |
| | 2-N2O-2009.xls | $N_2O$ emissions from Category2 (Industrial Processes) |
| | 2-NMVOC-2009.xls | NMVOC emissions from Category2 (Industrial Processes) |
| 3. Solvent and Other Product Use | 3A-NMVOC-2009.xls | NMVOC emissions from paint application use |
| | 3B-NMVOC-2009.xls | NMVOC emissions from dry cleaning & Degreasing |
| | 3C-NMVOC-2009.xls | NMVOC emissions from paint production, ink production & use, polyethylene laminate, solvent-type adhesive use and gum solvent use |
| | 3D-NMVOC-2009.xls | NMVOC emissions from other solvent |
| | 3-N2O-2009.xls | $N_2O$ emissions from anesthesia |

Table 2 Explanation of each MS Excel file (continued)

| category | file name | contents |
|---|---|---|
| 4. Agriculture | 4A-CH4-2009.xls | $CH_4$ emissions from enteric fermentation |
| | 4-AD-2009.xls | Activity Data of Caotegory4 |
| | 4B-CH4-2009.xls | $CH_4$ emissions from manure management |
| | 4B-N2O-2009.xls | $N_2O$ emissions from manure management |
| | 4C-CH4-2009.xls | $CH_4$ emissions from rice cultivation |
| | 4D-N2O-2009.xls | $N_2O$ emissions from agricultural soils |
| | 4F-CH4-2009.xls | $CH_4$ emissions from field burning of agricultural residues |
| | 4F-CO-2009.xls | CO emissions from field burning of agricultural residues |
| | 4F-N2O-2009.xls | $N_2O$ emissions from field burning of agricultural residues |
| 5. LULUCF | 5(III)-N2O-2009.xls | $N_2O$ emissions from disturbance associated with land use conversion to cropland |
| | 5(IV)-CO2-2009 | $CO_2$ emissions from agricultural lime application |
| | 5(V)-Burning-2009.xls | GHGs ($CH_4$, $N_2O$, CO, $NO_x$) emission from biomass burning |
| | 5A-CO2-2009.xls | $CO_2$ emissions and removals from forest land |
| | 5-AD-2009.xls | Area of land and land use change (Activity data for Category 5) |
| | 5B-CO2-2009.xls | $CO_2$ emissions and removals from cropland |
| | 5C-CO2-2009.xls | $CO_2$ emissions and removals from grassland |
| | 5D-CO2-2009.xls | $CO_2$ emissions and removals from wetlands |
| | 5E-CO2-2009.xls | $CO_2$ emissions and removals from settlements |
| | 5-EF-2009.xls | Emission Factors of Category5 |
| | 5F-CO2-2009.xls | $CO_2$ emissions and removals from other land |
| 6. Waste | 6A3-AD-2009.xls | Activity data of solid waste disposal on land (other) |
| | 6A-2009.xls | GHGs emissions from solid waste disposal on land |
| | 6A-AD-2009.xls | Activity data of solid waste disposal on land |
| | 6B-2009.xls | GHGs emissions from wastewater handling |
| | 6B-AD-2009.xls | Activity data of wastewater handling |
| | 6C-2009.xls | GHGs emissions from waste incineration (exclude $CO_2$) |
| | 6C-AD-2009.xls | Activity data of waste incineration |
| | 6C-CO2-2009.xls | $CO_2$ emissions from waste incineration |
| | 6C-Energy-2009.xls | GHGs (CO2, CH4, N2O, CO, NOx, SOx, NMVOC) Emissions from the incineration of waste for energy and use as alternative fuels |
| | 6C-Waste-2009.xls | GHGs (CO2, CH4, N2O, CO, NOx, SOx, NMVOC) Emissions from the simple incineration of waste |
| | 6D-2009.xls | GHGs emissions from other waste |
| | 6A-AD-2009.xls | Activity data of other waste |
| | 6-EF-2009.xls | Emission Factors of Category6 |
| | 6-ID-2009.xls | Background data for waste sector |
| 7. Other | 7-2009.xls | CO Emissions from tobaccos |
| Memo Item | bunker-2009.xls | GHGs emissions from bunker fuels |

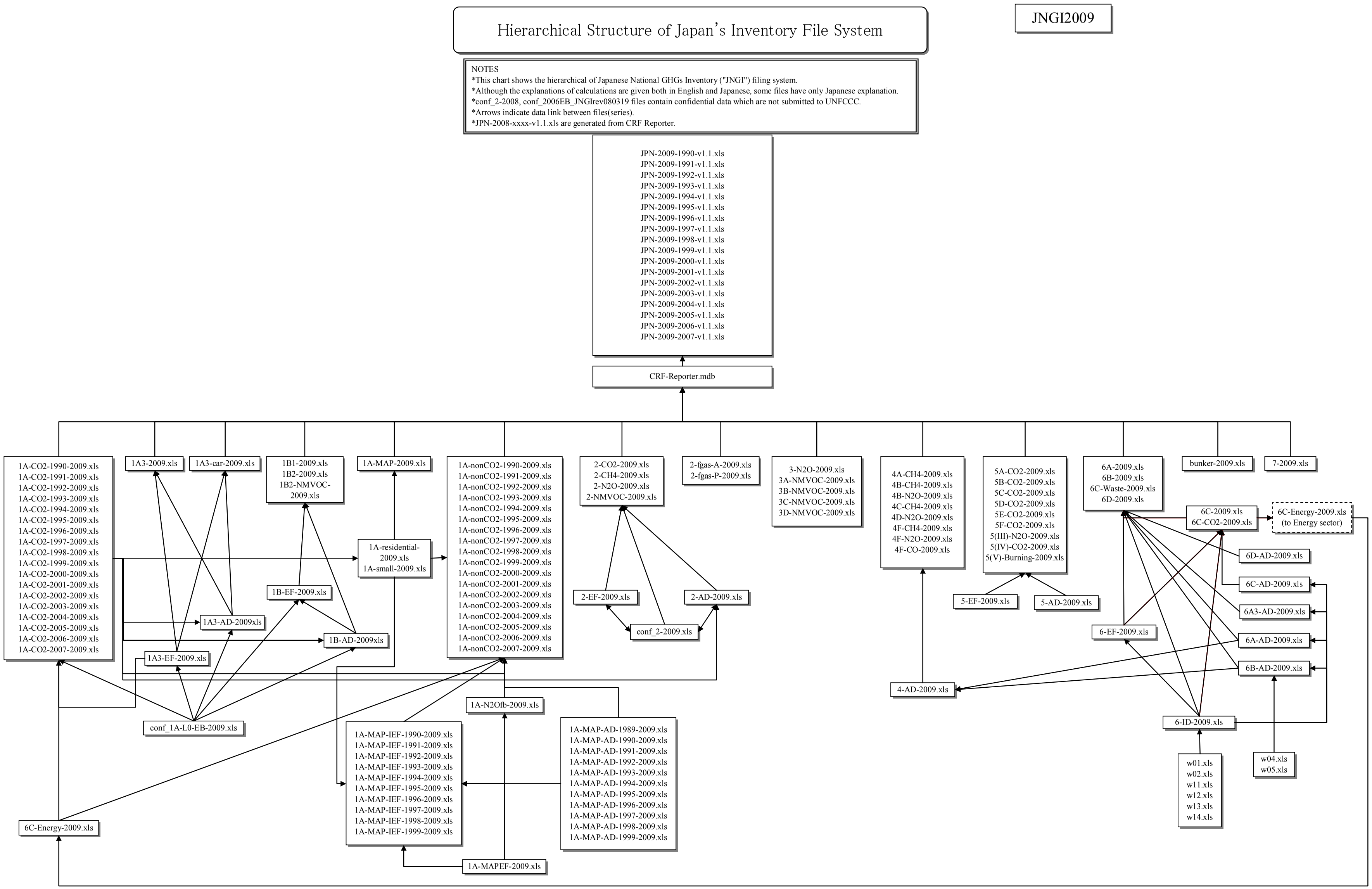



Figure 1 Hierarchical structure of Japan's National GHG Inventory File System

# Annex 9. Summary of Common Reporting Format

"Summary.2 Table" of the CRF indicated below shows emissions and removals for every year. During 1990-1994, Japan had reported only potential emissions of HFCs, PFCs, and $SF_6$. In Table.10 of the CRF showing the trend each year, between 1990 and 1994, the potential emissions of HFCs, PFCs, and $SF_6$ are shown, and from 1995 onward, actual emissions of HFCs, PFCs, $SF_6$ are shown.

## 9.1. Emissions[1] and Removals in 1990

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1990
Submission 2009 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)** | **1,068,836.90** | **32,630.50** | **32,062.86** | **17,930.00** | **5,670.00** | **38,240.00** | **1,195,370.26** |
| **1. Energy** | **1,068,055.66** | **3,918.50** | **6,923.55** | | | | **1,078,897.71** |
| A. Fuel Combustion (Sectoral Approach) | 1,068,019.04 | 881.36 | 6,923.44 | | | | 1,075,823.83 |
| 1. Energy Industries | 324,014.23 | 29.73 | 919.81 | | | | 324,963.77 |
| 2. Manufacturing Industries and Construction | 371,309.88 | 347.40 | 1,527.17 | | | | 373,184.45 |
| 3. Transport | 211,053.69 | 297.11 | 4,204.15 | | | | 215,554.95 |
| 4. Other Sectors | 161,641.24 | 207.12 | 272.31 | | | | 162,120.66 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 36.62 | 3,037.14 | 0.11 | | | | 3,073.88 |
| 1. Solid Fuels | NE,NO | 2,806.43 | NE,NO | | | | 2,806.43 |
| 2. Oil and Natural Gas | 36.62 | 230.71 | 0.11 | | | | 267.45 |
| **2. Industrial Processes** | **62,269.01** | **357.58** | **8,266.95** | **17,930.00** | **5,670.00** | **38,240.00** | **132,733.54** |
| A. Mineral Products | 57,398.95 | NA,NO | NA,NO | | | | 57,398.95 |
| B. Chemical Industry | 4,513.97 | 338.22 | 8,266.95 | NA | NA | NA | 13,119.14 |
| C. Metal Production | 356.09 | 19.36 | NO | IE,NE | IE,NA,NE | IE,NA,NE | 375.45 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | NE,NO | NE,NO | NE,NO | NE,NO |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 17,930.00 | 5,670.00 | 38,240.00 | 61,840.00 |
| G. Other | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **287.07** | | | | **287.07** |
| **4. Agriculture** | | **17,911.73** | **13,695.95** | | | | **31,607.68** |
| A. Enteric Fermentation | | 7,674.46 | | | | | 7,674.46 |
| B. Manure Management | | 3,104.72 | 5,661.40 | | | | 8,766.12 |
| C. Rice Cultivation | | 7,002.78 | | | | | 7,002.78 |
| D. Agricultural Soils(3) | | NA | 7,930.63 | | | | 7,930.63 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 129.77 | 103.92 | | | | 233.69 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-74,364.32** | **8.31** | **69.12** | | | | **-74,286.89** |
| A. Forest Land | -80,777.83 | 8.31 | 0.84 | | | | -80,768.68 |
| B. Cropland | 2,057.84 | NE,NO | 68.27 | | | | 2,126.11 |
| C. Grassland | -516.21 | NE,NO | NE,NO | | | | -516.21 |
| D. Wetlands | 292.33 | NE,NO | NE,NO | | | | 292.33 |
| E. Settlements | 3,072.68 | NE,NO | NE,NO | | | | 3,072.68 |
| F. Other Land | 956.66 | NE,NO | NE,NO | | | | 956.66 |
| G. Other | 550.22 | NA,NE | NA,NE | | | | 550.22 |
| **6. Waste** | **12,876.54** | **10,434.38** | **2,820.22** | | | | **26,131.15** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 8,285.86 | | | | | 8,285.86 |
| B. Waste-water Handling | | 2,120.57 | 1,289.65 | | | | 3,410.22 |
| C. Waste Incineration | 12,173.71 | 13.47 | 1,517.74 | | | | 13,704.93 |
| D. Other | 702.83 | 14.48 | 12.83 | | | | 730.14 |
| **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 | 42.30 | 275.80 | | | | 31,147.29 |
| Aviation | 13,189.32 | 7.84 | 130.44 | | | | 13,327.60 |
| Marine | 17,639.86 | 34.47 | 145.36 | | | | 17,819.69 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,747.30** | | | | | | **18,747.30** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,269,657.15 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,195,370.26 |

(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.

1 Potential emissions of HFCs, PFCs and $SF_6$ are reported due to the generation of CRF Reporter

## 9.2. Emissions[2] and Removals in 1991

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1991
Submission 2009 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)** | **1,078,378.74** | **32,384.24** | **31,524.61** | **18,070.00** | **6,370.00** | **43,498.00** | **1,210,225.59** |
| **1. Energy** | **1,075,882.90** | **3,681.63** | **7,219.76** | | | | **1,086,784.28** |
| A. Fuel Combustion (Sectoral Approach) | 1,075,829.23 | 886.87 | 7,219.59 | | | | 1,083,935.70 |
| 1. Energy Industries | 326,759.07 | 31.17 | 960.37 | | | | 327,750.61 |
| 2. Manufacturing Industries and Construction | 366,288.43 | 347.45 | 1,613.29 | | | | 368,249.17 |
| 3. Transport | 222,466.79 | 299.48 | 4,367.17 | | | | 227,133.45 |
| 4. Other Sectors | 160,314.95 | 208.77 | 278.75 | | | | 160,802.47 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 53.67 | 2,794.76 | 0.16 | | | | 2,848.59 |
| 1. Solid Fuels | NE,NO | 2,538.33 | NE,NO | | | | 2,538.33 |
| 2. Oil and Natural Gas | 53.67 | 256.43 | 0.16 | | | | 310.26 |
| **2. Industrial Processes** | **63,824.47** | **347.49** | **7,539.75** | **18,070.00** | **6,370.00** | **43,498.00** | **139,649.71** |
| A. Mineral Products | 59,001.27 | NA,NO | NA,NO | | | | 59,001.27 |
| B. Chemical Industry | 4,500.16 | 329.15 | 7,539.75 | NA | NA | NA | 12,369.06 |
| C. Metal Production | 323.04 | 18.34 | NO | IE,NE | IE,NA,NE | IE,NA,NE | 341.38 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | NE,NO | NE,NO | NE,NO | NE,NO |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 18,070.00 | 6,370.00 | 43,498.00 | 67,938.00 |
| G. Other | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **356.85** | | | | **356.85** |
| **4. Agriculture** | | **18,033.03** | **13,466.04** | | | | **31,499.07** |
| A. Enteric Fermentation | | 7,785.46 | | | | | 7,785.46 |
| B. Manure Management | | 3,099.71 | 5,607.91 | | | | 8,707.62 |
| C. Rice Cultivation | | 7,020.95 | | | | | 7,020.95 |
| D. Agricultural Soils(3) | | NA | 7,759.76 | | | | 7,759.76 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 126.91 | 98.37 | | | | 225.28 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-74,253.72** | **6.22** | **64.58** | | | | **-74,182.92** |
| A. Forest Land | -80,734.82 | 6.22 | 0.63 | | | | -80,727.98 |
| B. Cropland | 1,618.87 | NE,NO | 63.95 | | | | 1,682.81 |
| C. Grassland | -490.42 | NE,NO | NE,NO | | | | -490.42 |
| D. Wetlands | 270.99 | NE,NO | NE,NO | | | | 270.99 |
| E. Settlements | 3,544.05 | NE,NO | NE,NO | | | | 3,544.05 |
| F. Other Land | 1,010.33 | NE,NO | NE,NO | | | | 1,010.33 |
| G. Other | 527.29 | NA,NE | NA,NE | | | | 527.29 |
| **6. Waste** | **12,925.09** | **10,315.87** | **2,877.64** | | | | **26,118.61** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 8,212.93 | | | | | 8,212.93 |
| B. Waste-water Handling | | 2,078.27 | 1,311.47 | | | | 3,389.74 |
| C. Waste Incineration | 12,238.65 | 13.07 | 1,555.89 | | | | 13,807.61 |
| D. Other | 686.45 | 11.60 | 10.28 | | | | 708.32 |
| **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 | 44.64 | 291.02 | | | | 32,867.64 |
| Aviation | 13,919.12 | 8.27 | 137.65 | | | | 14,065.05 |
| Marine | 18,612.86 | 36.36 | 153.37 | | | | 18,802.60 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,870.94** | | | | | | **18,870.94** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,284,408.52 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,210,225.59 |

(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.

2 Potential emissions of HFCs, PFCs and $SF_6$ are reported due to the generation of CRF Reporter

## 9.3. Emissions[3] and Removals in 1992

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1992
Submission 2009 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)** | **1,086,957.65** | **32,110.24** | **31,602.32** | **19,750.00** | **6,370.00** | **47,800.00** | **1,224,590.21** |
| **1. Energy** | **1,083,354.31** | **3,429.22** | **7,386.13** | | | | **1,094,169.66** |
| A. Fuel Combustion (Sectoral Approach) | 1,083,297.36 | 901.88 | 7,385.96 | | | | 1,091,585.20 |
| 1. Energy Industries | 333,516.10 | 31.86 | 938.32 | | | | 334,486.28 |
| 2. Manufacturing Industries and Construction | 358,433.53 | 343.71 | 1,698.60 | | | | 360,475.85 |
| 3. Transport | 226,859.69 | 302.54 | 4,459.19 | | | | 231,621.42 |
| 4. Other Sectors | 164,488.04 | 223.76 | 289.85 | | | | 165,001.65 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 56.95 | 2,527.34 | 0.17 | | | | 2,584.46 |
| 1. Solid Fuels | NE,NO | 2,267.52 | NE,NO | | | | 2,267.52 |
| 2. Oil and Natural Gas | 56.95 | 259.82 | 0.17 | | | | 316.94 |
| **2. Industrial Processes** | **63,478.22** | **322.22** | **7,452.41** | **19,750.00** | **6,370.00** | **47,800.00** | **145,172.85** |
| A. Mineral Products | 58,772.68 | NA,NO | NA,NO | | | | 58,772.68 |
| B. Chemical Industry | 4,380.50 | 304.45 | 7,452.41 | NA | NA | NA | 12,137.36 |
| C. Metal Production | 325.05 | 17.76 | NO | IE,NE | IE,NA,NE | IE,NA,NE | 342.81 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | NE,NO | NE,NO | NE,NO | NE,NO |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 19,750.00 | 6,370.00 | 47,800.00 | 73,920.00 |
| G. Other | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **413.01** | | | | **413.01** |
| **4. Agriculture** | | **18,118.25** | **13,291.47** | | | | **31,409.72** |
| A. Enteric Fermentation | | 7,827.37 | | | | | 7,827.37 |
| B. Manure Management | | 3,072.48 | 5,559.72 | | | | 8,632.20 |
| C. Rice Cultivation | | 7,102.75 | | | | | 7,102.75 |
| D. Agricultural Soils(3) | | NA | 7,641.04 | | | | 7,641.04 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 115.64 | 90.72 | | | | 206.36 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-73,889.16** | **4.34** | **60.80** | | | | **-73,824.02** |
| A. Forest Land | -80,693.82 | 4.34 | 0.44 | | | | -80,689.05 |
| B. Cropland | 1,634.60 | NE,NO | 60.36 | | | | 1,694.96 |
| C. Grassland | -435.20 | NE,NO | NE,NO | | | | -435.20 |
| D. Wetlands | 366.62 | NE,NO | NE,NO | | | | 366.62 |
| E. Settlements | 3,853.47 | NE,NO | NE,NO | | | | 3,853.47 |
| F. Other Land | 908.06 | NE,NO | NE,NO | | | | 908.06 |
| G. Other | 477.11 | NA,NE | NA,NE | | | | 477.11 |
| **6. Waste** | **14,014.27** | **10,236.22** | **2,998.49** | | | | **27,248.99** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 8,171.57 | | | | | 8,171.57 |
| B. Waste-water Handling | | 2,039.32 | 1,296.47 | | | | 3,335.78 |
| C. Waste Incineration | 13,315.38 | 13.42 | 1,691.47 | | | | 15,020.27 |
| D. Other | 698.90 | 11.91 | 10.55 | | | | 721.37 |
| **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 | 45.03 | 294.87 | | | | 33,277.18 |
| Aviation | 14,216.76 | 8.45 | 140.60 | | | | 14,365.81 |
| Marine | 18,720.51 | 36.58 | 154.28 | | | | 18,911.37 |
| **Multilateral Operations** | NO | NO | NO | | | | NO |
| **$CO_2$ Emissions from Biomass** | **18,419.27** | | | | | | **18,419.27** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,298,414.23 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,224,590.21 |

(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.

3 Potential emissions of HFCs, PFCs and $SF_6$ are reported due to the generation of CRF Reporter

## 9.4. Emissions[4] and Removals in 1993

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1993
Submission 2009 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)** | **1,078,622.21** | **31,856.10** | **31,339.30** | **21,310.00** | **8,860.00** | **45,410.00** | **1,217,397.62** |
| **1. Energy** | **1,077,043.50** | **3,261.47** | **7,421.52** | | | | **1,087,726.49** |
| A. Fuel Combustion (Sectoral Approach) | 1,076,990.29 | 922.24 | 7,421.36 | | | | 1,085,333.88 |
| 1. Energy Industries | 315,452.73 | 31.65 | 949.84 | | | | 316,434.22 |
| 2. Manufacturing Industries and Construction | 357,524.88 | 345.84 | 1,716.77 | | | | 359,587.49 |
| 3. Transport | 231,727.93 | 295.38 | 4,432.03 | | | | 236,455.34 |
| 4. Other Sectors | 172,284.75 | 249.36 | 322.72 | | | | 172,856.82 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 53.21 | 2,339.23 | 0.16 | | | | 2,392.61 |
| 1. Solid Fuels | NE,NO | 2,075.76 | NE,NO | | | | 2,075.76 |
| 2. Oil and Natural Gas | 53.21 | 263.46 | 0.16 | | | | 316.84 |
| **2. Industrial Processes** | **62,722.20** | **320.55** | **7,302.85** | **21,310.00** | **8,860.00** | **45,410.00** | **145,925.60** |
| A. Mineral Products | 58,234.79 | NA,NO | NA,NO | | | | 58,234.79 |
| B. Chemical Industry | 4,156.65 | 303.85 | 7,302.85 | NA | NA | NA | 11,763.35 |
| C. Metal Production | 330.76 | 16.70 | NO | IE,NE | IE,NA,NE | IE,NA,NE | 347.46 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | NE,NO | NE,NO | NE,NO | NE,NO |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 21,310.00 | 8,860.00 | 45,410.00 | 75,580.00 |
| G. Other | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **411.66** | | | | **411.66** |
| **4. Agriculture** | | **18,204.03** | **13,137.28** | | | | **31,341.31** |
| A. Enteric Fermentation | | 7,779.71 | | | | | 7,779.71 |
| B. Manure Management | | 3,013.19 | 5,462.75 | | | | 8,475.95 |
| C. Rice Cultivation | | 7,292.48 | | | | | 7,292.48 |
| D. Agricultural Soils(3) | | NA | 7,584.10 | | | | 7,584.10 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 118.65 | 90.43 | | | | 209.08 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-74,945.32** | **23.91** | **59.04** | | | | **-74,862.37** |
| A. Forest Land | -80,644.21 | 23.91 | 2.43 | | | | -80,617.88 |
| B. Cropland | 1,208.75 | NE,NO | 56.61 | | | | 1,265.36 |
| C. Grassland | -456.09 | NE,NO | NE,NO | | | | -456.09 |
| D. Wetlands | 265.33 | NE,NO | NE,NO | | | | 265.33 |
| E. Settlements | 3,159.32 | NE,NO | NE,NO | | | | 3,159.32 |
| F. Other Land | 1,040.02 | NE,NO | NE,NO | | | | 1,040.02 |
| G. Other | 481.56 | NA,NE | NA,NE | | | | 481.56 |
| **6. Waste** | **13,801.83** | **10,046.15** | **3,006.95** | | | | **26,854.92** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 8,032.66 | | | | | 8,032.66 |
| B. Waste-water Handling | | 1,987.68 | 1,300.14 | | | | 3,287.82 |
| C. Waste Incineration | 13,121.08 | 13.35 | 1,695.77 | | | | 14,830.21 |
| D. Other | 680.75 | 12.45 | 11.03 | | | | 704.22 |
| **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 | 49.40 | 310.66 | | | | 35,295.26 |
| Aviation | 13,856.19 | 8.23 | 137.03 | | | | 14,001.45 |
| Marine | 21,079.01 | 41.17 | 173.63 | | | | 21,293.81 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **17,568.73** | | | | | | **17,568.73** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,292,259.98 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,217,397.62 |

(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.

4 Potential emissions of HFCs, PFCs and $SF_6$ are reported due to the generation of CRF Reporter

## 9.5. Emissions[5] and Removals in 1994

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1994
Submission 2009 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)** | **1,137,765.93** | **31,167.61** | **32,515.71** | **28,840.00** | **12,274.00** | **45,410.00** | **1,287,973.25** |
| **1. Energy** | **1,133,119.23** | **2,900.81** | **7,746.99** | | | | **1,143,767.03** |
| A. Fuel Combustion (Sectoral Approach) | 1,133,068.08 | 921.28 | 7,746.83 | | | | 1,141,736.19 |
| 1. Energy Industries | 356,214.60 | 33.80 | 1,025.56 | | | | 357,273.96 |
| 2. Manufacturing Industries and Construction | 365,932.03 | 355.24 | 1,881.91 | | | | 368,169.18 |
| 3. Transport | 243,681.03 | 297.10 | 4,513.33 | | | | 248,491.46 |
| 4. Other Sectors | 167,240.42 | 235.14 | 326.03 | | | | 167,801.59 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 51.15 | 1,979.53 | 0.16 | | | | 2,030.84 |
| 1. Solid Fuels | NE,NO | 1,712.96 | NE,NO | | | | 1,712.96 |
| 2. Oil and Natural Gas | 51.15 | 266.57 | 0.16 | | | | 317.88 |
| **2. Industrial Processes** | **64,008.03** | **320.85** | **8,298.10** | **28,840.00** | **12,274.00** | **45,410.00** | **159,150.98** |
| A. Mineral Products | 59,228.96 | NA,NO | NA,NO | | | | 59,228.96 |
| B. Chemical Industry | 4,433.31 | 303.40 | 8,298.10 | NA | NA | NA | 13,034.81 |
| C. Metal Production | 345.76 | 17.45 | NO | IE,NE | IE,NA,NE | IE,NA,NE | 363.21 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | NE,NO | NE,NO | NE,NO | NE,NO |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 28,840.00 | 12,274.00 | 45,410.00 | 86,524.00 |
| G. Other | NO | NO | NO | NE,NO | NE,NO | NE,NO | NE,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **438.02** | | | | **438.02** |
| **4. Agriculture** | | **18,068.88** | **12,849.45** | | | | **30,918.33** |
| A. Enteric Fermentation | | 7,691.24 | | | | | 7,691.24 |
| B. Manure Management | | 2,952.92 | 5,346.66 | | | | 8,299.58 |
| C. Rice Cultivation | | 7,308.38 | | | | | 7,308.38 |
| D. Agricultural Soils(3) | | NA | 7,414.54 | | | | 7,414.54 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 116.35 | 88.24 | | | | 204.59 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-75,705.65** | **17.75** | **48.93** | | | | **-75,638.97** |
| A. Forest Land | -80,583.14 | 17.75 | 1.80 | | | | -80,563.58 |
| B. Cropland | 1,044.34 | NE,NO | 47.13 | | | | 1,091.47 |
| C. Grassland | -416.04 | NE,NO | NE,NO | | | | -416.04 |
| D. Wetlands | 258.67 | NE,NO | NE,NO | | | | 258.67 |
| E. Settlements | 2,667.64 | NE,NO | NE,NO | | | | 2,667.64 |
| F. Other Land | 1,030.13 | NE,NO | NE,NO | | | | 1,030.13 |
| G. Other | 292.73 | NA,NE | NA,NE | | | | 292.73 |
| **6. Waste** | **16,344.34** | **9,859.31** | **3,134.23** | | | | **29,337.87** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 7,912.13 | | | | | 7,912.13 |
| B. Waste-water Handling | | 1,921.54 | 1,264.75 | | | | 3,186.29 |
| C. Waste Incineration | 15,642.42 | 14.48 | 1,859.59 | | | | 17,516.50 |
| D. Other | 701.91 | 11.15 | 9.88 | | | | 722.95 |
| **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 | 50.02 | 322.19 | | | | 36,465.90 |
| Aviation | 15,066.49 | 8.95 | 149.00 | | | | 15,224.44 |
| Marine | 21,027.20 | 41.06 | 173.19 | | | | 21,241.46 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **17,803.39** | | | | | | **17,803.39** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,363,612.22 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,287,973.25 |

(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.

5 Potential emissions of HFCs, PFCs and $SF_6$ are reported due to the generation of CRF Reporter

## 9.6. Emissions and Removals in 1995

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1995
Submission 2009 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)** | **1,147,028.46** | **30,228.55** | **32,885.04** | **20,260.58** | **14,363.46** | **16,961.78** | **1,261,727.86** |
| **1. Energy** | **1,145,732.91** | **2,565.25** | **8,380.66** | | | | **1,156,678.82** |
| A. Fuel Combustion (Sectoral Approach) | 1,145,681.98 | 955.38 | 8,380.51 | | | | 1,155,017.87 |
| 1. Energy Industries | 344,805.01 | 34.42 | 1,454.77 | | | | 346,294.20 |
| 2. Manufacturing Industries and Construction | 370,592.23 | 357.68 | 1,939.93 | | | | 372,889.84 |
| 3. Transport | 251,161.43 | 308.32 | 4,649.77 | | | | 256,119.52 |
| 4. Other Sectors | 179,123.31 | 254.95 | 336.05 | | | | 179,714.31 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 50.92 | 1,609.87 | 0.16 | | | | 1,660.95 |
| 1. Solid Fuels | NE,NO | 1,344.68 | NE,NO | | | | 1,344.68 |
| 2. Oil and Natural Gas | 50.92 | 265.19 | 0.16 | | | | 316.26 |
| **2. Industrial Processes** | **64,223.15** | **322.37** | **8,212.71** | **20,260.58** | **14,363.46** | **16,961.78** | **124,344.05** |
| A. Mineral Products | 59,340.46 | NA,NO | NA,NO | | | | 59,340.46 |
| B. Chemical Industry | 4,525.47 | 304.45 | 8,212.71 | NA | NA | NA | 13,042.62 |
| C. Metal Production | 357.22 | 17.92 | NO | IE,NE | 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) | | | | 2,815.46 | 13,530.88 | 12,133.98 | 28,480.32 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **437.58** | | | | **437.58** |
| **4. Agriculture** | | **17,756.13** | **12,552.12** | | | | **30,308.25** |
| A. Enteric Fermentation | | 7,605.16 | | | | | 7,605.16 |
| B. Manure Management | | 2,903.14 | 5,245.71 | | | | 8,148.85 |
| C. Rice Cultivation | | 7,126.61 | | | | | 7,126.61 |
| D. Agricultural Soils(3) | | NA | 7,217.71 | | | | 7,217.71 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 121.22 | 88.70 | | | | 209.92 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-79,546.36** | **8.66** | **41.98** | | | | **-79,495.72** |
| A. Forest Land | -84,364.58 | 8.66 | 0.88 | | | | -84,355.05 |
| B. Cropland | 973.81 | NE,NO | 41.10 | | | | 1,014.91 |
| C. Grassland | -400.61 | NE,NO | NE,NO | | | | -400.61 |
| D. Wetlands | 354.72 | NE,NO | NE,NO | | | | 354.72 |
| E. Settlements | 2,582.88 | NE,NO | NE,NO | | | | 2,582.88 |
| F. Other Land | 1,003.93 | NE,NO | NE,NO | | | | 1,003.93 |
| G. Other | 303.50 | NA,NE | NA,NE | | | | 303.50 |
| **6. Waste** | **16,618.75** | **9,576.14** | **3,260.00** | | | | **29,454.89** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 7,689.10 | | | | | 7,689.10 |
| B. Waste-water Handling | | 1,860.70 | 1,247.18 | | | | 3,107.88 |
| C. Waste Incineration | 15,950.93 | 14.86 | 2,002.65 | | | | 17,968.44 |
| D. Other | 667.83 | 11.48 | 10.17 | | | | 689.48 |
| **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 | 51.56 | 342.39 | | | | 38,573.71 |
| Aviation | 16,922.99 | 10.06 | 167.36 | | | | 17,100.41 |
| Marine | 21,256.78 | 41.50 | 175.03 | | | | 21,473.30 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,487.35** | | | | | | **18,487.35** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,341,223.59 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,261,727.86 |

(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.

## 9.7. Emissions and Removals in 1996

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1996
Submission 2009 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)** | **1,159,046.20** | **29,559.40** | **33,943.34** | **19,906.44** | **14,893.37** | **17,535.58** | **1,274,884.34** |
| **1. Energy** | **1,157,887.62** | **2,515.56** | **8,597.81** | | | | **1,169,001.00** |
| A. Fuel Combustion (Sectoral Approach) | 1,157,838.26 | 955.07 | 8,597.66 | | | | 1,167,390.98 |
| 1. Energy Industries | 345,005.22 | 36.21 | 1,484.31 | | | | 346,525.74 |
| 2. Manufacturing Industries and Construction | 378,859.35 | 374.67 | 2,075.47 | | | | 381,309.48 |
| 3. Transport | 256,736.87 | 314.14 | 4,736.65 | | | | 261,787.66 |
| 4. Other Sectors | 177,236.82 | 230.05 | 301.23 | | | | 177,768.10 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 49.37 | 1,560.49 | 0.15 | | | | 1,610.01 |
| 1. Solid Fuels | NE,NO | 1,297.15 | NE,NO | | | | 1,297.15 |
| 2. Oil and Natural Gas | 49.37 | 263.34 | 0.15 | | | | 312.86 |
| **2. Industrial Processes** | **63,988.68** | **312.02** | **9,220.07** | **19,906.44** | **14,893.37** | **17,535.58** | **125,856.17** |
| A. Mineral Products | 59,113.10 | NA,NO | NA,NO | | | | 59,113.10 |
| B. Chemical Industry | 4,495.60 | 293.80 | 9,220.07 | NA | NA | NA | 14,009.47 |
| C. Metal Production | 379.99 | 18.22 | NO | IE,NE | 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) | | | | 3,854.13 | 13,819.70 | 13,209.68 | 30,883.51 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **420.94** | | | | **420.94** |
| **4. Agriculture** | | **17,370.86** | **12,261.57** | | | | **29,632.43** |
| A. Enteric Fermentation | | 7,549.92 | | | | | 7,549.92 |
| B. Manure Management | | 2,869.11 | 5,183.49 | | | | 8,052.60 |
| C. Rice Cultivation | | 6,835.77 | | | | | 6,835.77 |
| D. Agricultural Soils(3) | | NA | 6,992.68 | | | | 6,992.68 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 116.06 | 85.41 | | | | 201.47 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-79,881.62** | **28.37** | **36.96** | | | | **-79,816.30** |
| A. Forest Land | -84,300.66 | 28.37 | 2.88 | | | | -84,269.42 |
| B. Cropland | 843.97 | NE,NO | 34.08 | | | | 878.04 |
| C. Grassland | -398.63 | NE,NO | NE,NO | | | | -398.63 |
| D. Wetlands | 527.22 | NE,NO | NE,NO | | | | 527.22 |
| E. Settlements | 2,189.68 | NE,NO | NE,NO | | | | 2,189.68 |
| F. Other Land | 964.10 | NE,NO | NE,NO | | | | 964.10 |
| G. Other | 292.70 | NA,NE | NA,NE | | | | 292.70 |
| **6. Waste** | **17,051.51** | **9,332.60** | **3,406.00** | | | | **29,790.11** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 7,480.02 | | | | | 7,480.02 |
| B. Waste-water Handling | | 1,825.56 | 1,268.68 | | | | 3,094.24 |
| C. Waste Incineration | 16,411.04 | 15.23 | 2,126.88 | | | | 18,553.15 |
| D. Other | 640.47 | 11.79 | 10.44 | | | | 662.70 |
| **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 | 35.39 | 285.44 | | | | 31,279.08 |
| Aviation | 18,441.91 | 10.96 | 182.38 | | | | 18,635.25 |
| Marine | 12,516.34 | 24.43 | 103.06 | | | | 12,643.83 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,547.51** | | | | | | **18,547.51** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,354,700.64 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,274,884.34 |

(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.

## 9.8. Emissions and Removals in 1997

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1997
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| 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)** | **1,154,724.37** | **28,494.82** | **34,582.62** | **19,905.27** | **16,286.37** | **15,047.20** | **1,269,040.66** |
| **1. Energy** | **1,154,899.81** | **2,222.46** | **8,860.28** | | | | **1,165,982.55** |
| A. Fuel Combustion (Sectoral Approach) | 1,154,851.84 | 945.21 | 8,860.14 | | | | 1,164,657.19 |
| 1. Energy Industries | 341,946.69 | 38.04 | 1,538.00 | | | | 343,522.73 |
| 2. Manufacturing Industries and Construction | 381,193.89 | 356.70 | 2,235.44 | | | | 383,786.02 |
| 3. Transport | 258,735.79 | 315.28 | 4,781.94 | | | | 263,833.01 |
| 4. Other Sectors | 172,975.47 | 235.19 | 304.77 | | | | 173,515.43 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 47.97 | 1,277.25 | 0.15 | | | | 1,325.37 |
| 1. Solid Fuels | NE,NO | 1,006.86 | NE,NO | | | | 1,006.86 |
| 2. Oil and Natural Gas | 47.97 | 270.39 | 0.15 | | | | 318.51 |
| **2. Industrial Processes** | **62,260.68** | **260.90** | **9,742.87** | **19,905.27** | **16,286.37** | **15,047.20** | **123,503.29** |
| A. Mineral Products | 57,433.11 | NA,NO | NA,NO | | | | 57,433.11 |
| B. Chemical Industry | 4,443.09 | 242.58 | 9,742.87 | NA | NA | NA | 14,428.53 |
| C. Metal Production | 384.48 | 18.33 | NO | IE,NE | 59.43 | 191.20 | 653.44 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 15,077.99 | 1,416.80 | 2,633.78 | 19,128.57 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 4,827.28 | 14,810.13 | 12,222.22 | 31,859.64 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **404.60** | | | | **404.60** |
| **4. Agriculture** | | **16,922.40** | **12,062.96** | | | | **28,985.35** |
| A. Enteric Fermentation | | 7,503.94 | | | | | 7,503.94 |
| B. Manure Management | | 2,826.62 | 5,127.76 | | | | 7,954.38 |
| C. Rice Cultivation | | 6,480.18 | | | | | 6,480.18 |
| D. Agricultural Soils(3) | | NA | 6,852.02 | | | | 6,852.02 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 111.66 | 83.18 | | | | 194.84 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-80,132.65** | **34.31** | **30.74** | | | | **-80,067.59** |
| A. Forest Land | -84,236.14 | 34.31 | 3.48 | | | | -84,198.35 |
| B. Cropland | 705.14 | NE,NO | 27.26 | | | | 732.41 |
| C. Grassland | -377.34 | NE,NO | NE,NO | | | | -377.34 |
| D. Wetlands | 255.71 | NE,NO | NE,NO | | | | 255.71 |
| E. Settlements | 2,052.66 | NE,NO | NE,NO | | | | 2,052.66 |
| F. Other Land | 1,163.71 | NE,NO | NE,NO | | | | 1,163.71 |
| G. Other | 303.61 | NA,NE | NA,NE | | | | 303.61 |
| **6. Waste** | **17,696.53** | **9,054.76** | **3,481.17** | | | | **30,232.45** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 7,248.79 | | | | | 7,248.79 |
| B. Waste-water Handling | | 1,778.95 | 1,278.90 | | | | 3,057.85 |
| C. Waste Incineration | 17,041.30 | 14.70 | 2,191.35 | | | | 19,247.35 |
| D. Other | 655.23 | 12.32 | 10.91 | | | | 678.46 |
| **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 | 43.17 | 323.34 | | | | 35,798.80 |
| Aviation | 19,134.37 | 11.37 | 189.23 | | | | 19,334.97 |
| Marine | 16,297.92 | 31.80 | 134.12 | | | | 16,463.84 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **19,107.10** | | | | | | **19,107.10** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,349,108.25 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,269,040.66 |

(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.

## 9.9. Emissions and Removals in 1998

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1998
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| 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)** | **1,118,847.59** | **27,658.43** | **33,137.73** | **19,416.11** | **13,530.79** | **13,643.98** | **1,226,234.63** |
| **1. Energy** | **1,125,006.43** | **2,053.36** | **8,754.47** | | | | **1,135,814.25** |
| A. Fuel Combustion (Sectoral Approach) | 1,124,963.70 | 915.38 | 8,754.33 | | | | 1,134,633.41 |
| 1. Energy Industries | 332,325.38 | 39.84 | 1,567.84 | | | | 333,933.05 |
| 2. Manufacturing Industries and Construction | 357,877.18 | 318.87 | 2,187.37 | | | | 360,383.42 |
| 3. Transport | 257,852.23 | 304.30 | 4,675.92 | | | | 262,832.45 |
| 4. Other Sectors | 176,908.91 | 252.38 | 323.21 | | | | 177,484.50 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 42.73 | 1,137.98 | 0.13 | | | | 1,180.84 |
| 1. Solid Fuels | NE,NO | 872.46 | NE,NO | | | | 872.46 |
| 2. Oil and Natural Gas | 42.73 | 265.52 | 0.13 | | | | 308.38 |
| **2. Industrial Processes** | **56,197.53** | **243.52** | **8,577.87** | **19,416.11** | **13,530.79** | **13,643.98** | **111,609.81** |
| A. Mineral Products | 51,998.72 | NA,NO | NA,NO | | | | 51,998.72 |
| B. Chemical Industry | 3,905.71 | 227.37 | 8,577.87 | NA | NA | NA | 12,710.95 |
| C. Metal Production | 293.11 | 16.15 | NO | IE,NE | 49.40 | 406.30 | 764.96 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 14,053.43 | 1,389.50 | 2,127.10 | 17,570.03 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 5,362.68 | 12,091.89 | 11,110.58 | 28,565.15 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **377.05** | | | | **377.05** |
| **4. Agriculture** | | **16,623.29** | **11,932.95** | | | | **28,556.23** |
| A. Enteric Fermentation | | 7,465.61 | | | | | 7,465.61 |
| B. Manure Management | | 2,780.70 | 5,085.14 | | | | 7,865.84 |
| C. Rice Cultivation | | 6,267.74 | | | | | 6,267.74 |
| D. Agricultural Soils(3) | | NA | 6,764.75 | | | | 6,764.75 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 109.24 | 83.05 | | | | 192.30 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-80,048.78** | **10.68** | **25.48** | | | | **-80,012.62** |
| A. Forest Land | -84,175.63 | 10.68 | 1.08 | | | | -84,163.86 |
| B. Cropland | 677.05 | NE,NO | 24.40 | | | | 701.45 |
| C. Grassland | -367.71 | NE,NO | NE,NO | | | | -367.71 |
| D. Wetlands | 413.05 | NE,NO | NE,NO | | | | 413.05 |
| E. Settlements | 2,034.73 | NE,NO | NE,NO | | | | 2,034.73 |
| F. Other Land | 1,069.75 | NE,NO | NE,NO | | | | 1,069.75 |
| G. Other | 299.97 | NA,NE | NA,NE | | | | 299.97 |
| **6. Waste** | **17,692.41** | **8,727.59** | **3,469.92** | | | | **29,889.91** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 6,967.17 | | | | | 6,967.17 |
| B. Waste-water Handling | | 1,733.45 | 1,261.98 | | | | 2,995.43 |
| C. Waste Incineration | 17,083.29 | 14.53 | 2,196.92 | | | | 19,294.74 |
| D. Other | 609.12 | 12.44 | 11.02 | | | | 632.58 |
| **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 | 45.77 | 340.73 | | | | 37,747.59 |
| Aviation | 20,001.55 | 11.89 | 197.80 | | | | 20,211.24 |
| Marine | 17,359.53 | 33.89 | 142.93 | | | | 17,536.35 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **17,556.58** | | | | | | **17,556.58** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,306,247.26 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,226,234.63 |

(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.

## 9.10. Emissions and Removals in 1999

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 1999
Submission 2009 v1.1
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| 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)** | **1,153,566.96** | **27,027.43** | **26,753.19** | **19,934.65** | **10,584.07** | **9,346.88** | **1,247,213.18** |
| **1. Energy** | **1,160,137.03** | **2,071.71** | **9,020.26** | | | | **1,171,229.00** |
| A. Fuel Combustion (Sectoral Approach) | 1,160,098.97 | 943.29 | 9,020.15 | | | | 1,170,062.40 |
| 1. Energy Industries | 349,727.88 | 42.70 | 1,695.50 | | | | 351,466.08 |
| 2. Manufacturing Industries and Construction | 365,112.29 | 321.91 | 2,304.02 | | | | 367,738.22 |
| 3. Transport | 260,040.59 | 302.88 | 4,662.22 | | | | 265,005.70 |
| 4. Other Sectors | 185,218.21 | 275.80 | 358.41 | | | | 185,852.41 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 38.06 | 1,128.42 | 0.12 | | | | 1,166.60 |
| 1. Solid Fuels | NE,NO | 865.69 | NE,NO | | | | 865.69 |
| 2. Oil and Natural Gas | 38.06 | 262.73 | 0.12 | | | | 300.91 |
| **2. Industrial Processes** | **56,195.37** | **236.22** | **2,000.86** | **19,934.65** | **10,584.07** | **9,346.88** | **98,298.05** |
| A. Mineral Products | 51,698.90 | NA,NO | NA,NO | | | | 51,698.90 |
| B. Chemical Industry | 4,241.98 | 220.14 | 2,000.86 | NA | NA | NA | 6,462.98 |
| C. Metal Production | 254.49 | 16.08 | NO | IE,NE | 29.12 | 645.30 | 944.99 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 14,260.55 | 1,270.88 | 1,570.23 | 17,101.66 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 5,674.09 | 9,284.07 | 7,131.35 | 22,089.51 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **362.53** | | | | **362.53** |
| **4. Agriculture** | | **16,304.19** | **11,841.98** | | | | **28,146.17** |
| A. Enteric Fermentation | | 7,406.63 | | | | | 7,406.63 |
| B. Manure Management | | 2,727.35 | 5,032.95 | | | | 7,760.30 |
| C. Rice Cultivation | | 6,062.11 | | | | | 6,062.11 |
| D. Agricultural Soils(3) | | NA | 6,727.08 | | | | 6,727.08 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 108.11 | 81.96 | | | | 190.06 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-80,304.04** | **5.20** | **23.28** | | | | **-80,275.56** |
| A. Forest Land | -84,115.40 | 5.20 | 0.53 | | | | -84,109.67 |
| B. Cropland | 632.36 | NE,NO | 22.75 | | | | 655.11 |
| C. Grassland | -396.84 | NE,NO | NE,NO | | | | -396.84 |
| D. Wetlands | 382.55 | NE,NO | NE,NO | | | | 382.55 |
| E. Settlements | 1,843.87 | NE,NO | NE,NO | | | | 1,843.87 |
| F. Other Land | 1,055.89 | NE,NO | NE,NO | | | | 1,055.89 |
| G. Other | 293.52 | NA,NE | NA,NE | | | | 293.52 |
| **6. Waste** | **17,538.60** | **8,410.11** | **3,504.27** | | | | **29,452.99** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 6,698.38 | | | | | 6,698.38 |
| B. Waste-water Handling | | 1,685.23 | 1,225.63 | | | | 2,910.86 |
| C. Waste Incineration | 16,886.03 | 14.03 | 2,267.59 | | | | 19,167.65 |
| D. Other | 652.58 | 12.48 | 11.05 | | | | 676.10 |
| **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 | 43.75 | 329.04 | | | | 36,395.28 |
| Aviation | 19,576.46 | 11.63 | 193.60 | | | | 19,781.70 |
| Marine | 16,446.03 | 32.11 | 135.44 | | | | 16,613.59 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,260.06** | | | | | | **18,260.06** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,327,488.74 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,247,213.18 |

(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.

## 9.11. Emissions and Removals in 2000

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2000
Submission 2009 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)] | **1,173,969.66** | **26,372.42** | **29,297.08** | **18,800.50** | **9,664.87** | **7,255.19** | **1,265,359.72** |
| **1. Energy** | **1,180,062.26** | **1,998.90** | **9,015.21** | | | | **1,191,076.38** |
| A. Fuel Combustion (Sectoral Approach) | 1,180,026.24 | 955.75 | 9,015.10 | | | | 1,189,997.09 |
| 1. Energy Industries | 357,482.45 | 43.66 | 1,765.27 | | | | 359,291.37 |
| 2. Manufacturing Industries and Construction | 377,013.61 | 344.76 | 2,327.12 | | | | 379,685.50 |
| 3. Transport | 259,204.38 | 297.97 | 4,561.12 | | | | 264,063.47 |
| 4. Other Sectors | 186,325.79 | 269.36 | 361.59 | | | | 186,956.75 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 36.03 | 1,043.15 | 0.11 | | | | 1,079.29 |
| 1. Solid Fuels | NE,NO | 769.13 | NE,NO | | | | 769.13 |
| 2. Oil and Natural Gas | 36.03 | 274.02 | 0.11 | | | | 310.16 |
| **2. Industrial Processes** | **56,838.55** | **181.23** | **4,690.09** | **18,800.50** | **9,664.87** | **7,255.19** | **97,430.43** |
| A. Mineral Products | 52,412.14 | NA,NO | NA,NO | | | | 52,412.14 |
| B. Chemical Industry | 4,177.99 | 164.40 | 4,690.09 | NA | NA | NA | 9,032.47 |
| C. Metal Production | 248.42 | 16.84 | NO | IE,NE | 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 | 932.10 | 14,950.94 |
| F. Consumption of Halocarbons and $SF_6$ [(2)] | | | | 6,140.66 | 8,288.08 | 5,295.39 | 19,724.13 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **340.99** | | | | **340.99** |
| **4. Agriculture** | | **16,126.59** | **11,759.07** | | | | **27,885.66** |
| A. Enteric Fermentation | | 7,374.09 | | | | | 7,374.09 |
| B. Manure Management | | 2,687.52 | 4,983.77 | | | | 7,671.29 |
| C. Rice Cultivation | | 5,956.45 | | | | | 5,956.45 |
| D. Agricultural Soils[(3)] | | NA | 6,694.13 | | | | 6,694.13 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 108.54 | 81.18 | | | | 189.71 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry**[(1)] | **-80,666.00** | **7.75** | **21.24** | | | | **-80,637.01** |
| A. Forest Land | -84,050.40 | 7.75 | 0.79 | | | | -84,041.86 |
| B. Cropland | 514.24 | NE,NO | 20.46 | | | | 534.70 |
| C. Grassland | -459.84 | NE,NO | NE,NO | | | | -459.84 |
| D. Wetlands | 407.19 | NE,NO | NE,NO | | | | 407.19 |
| E. Settlements | 1,662.91 | NE,NO | NE,NO | | | | 1,662.91 |
| F. Other Land | 927.03 | NE,NO | NE,NO | | | | 927.03 |
| G. Other | 332.87 | NA,NE | NA,NE | | | | 332.87 |
| **6. Waste** | **17,734.85** | **8,057.94** | **3,470.47** | | | | **29,263.26** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 6,394.39 | | | | | 6,394.39 |
| B. Waste-water Handling | | 1,636.91 | 1,213.64 | | | | 2,850.55 |
| C. Waste Incineration | 17,078.93 | 13.33 | 2,245.04 | | | | 19,337.30 |
| D. Other | 655.91 | 13.31 | 11.79 | | | | 681.02 |
| **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 | 45.17 | 333.30 | | | | 37,110.35 |
| Aviation | 19,542.61 | 11.61 | 191.78 | | | | 19,746.00 |
| Marine | 17,189.28 | 33.55 | 141.52 | | | | 17,364.35 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,846.04** | | | | | | **18,846.04** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,345,996.72 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,265,359.72 |

(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.

## 9.12. Emissions and Removals in 2001

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2001
Submission 2009 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)] | **1,157,979.40** | **25,607.97** | **25,832.72** | **16,168.43** | **8,072.31** | **6,041.49** | **1,239,702.33** |
| **1. Energy** | **1,167,567.34** | **1,767.57** | **9,016.92** | | | | **1,178,351.83** |
| A. Fuel Combustion (Sectoral Approach) | 1,167,534.90 | 929.39 | 9,016.82 | | | | 1,177,481.11 |
| 1. Energy Industries | 349,717.22 | 43.71 | 1,810.66 | | | | 351,571.58 |
| 2. Manufacturing Industries and Construction | 367,541.37 | 323.86 | 2,465.48 | | | | 370,330.70 |
| 3. Transport | 261,752.88 | 292.43 | 4,377.65 | | | | 266,422.96 |
| 4. Other Sectors | 188,523.44 | 269.39 | 363.04 | | | | 189,155.86 |
| 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** | **54,714.54** | **147.48** | **1,414.89** | **16,168.43** | **8,072.31** | **6,041.49** | **86,559.14** |
| A. Mineral Products | 50,646.83 | NA,NO | NA,NO | | | | 50,646.83 |
| B. Chemical Industry | 3,857.00 | 131.64 | 1,414.89 | NA | NA | NA | 5,403.52 |
| C. Metal Production | 210.71 | 15.84 | NO | IE,NE | 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 | 869.96 | 11,665.99 |
| F. Consumption of Halocarbons and $SF_6$ [(2)] | | | | 6,455.00 | 6,973.98 | 4,024.33 | 17,453.32 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **343.60** | | | | **343.60** |
| **4. Agriculture** | | **15,955.52** | **11,655.68** | | | | **27,611.20** |
| A. Enteric Fermentation | | 7,339.19 | | | | | 7,339.19 |
| B. Manure Management | | 2,661.66 | 4,936.91 | | | | 7,598.57 |
| C. Rice Cultivation | | 5,846.25 | | | | | 5,846.25 |
| D. Agricultural Soils[(3)] | | NA | 6,638.84 | | | | 6,638.84 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 108.43 | 79.92 | | | | 188.35 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry**[(1)] | **-80,821.13** | **12.34** | **19.60** | | | | **-80,789.19** |
| A. Forest Land | -83,989.82 | 12.34 | 1.25 | | | | -83,976.23 |
| B. Cropland | 446.64 | NE,NO | 18.34 | | | | 464.98 |
| C. Grassland | -473.64 | NE,NO | NE,NO | | | | -473.64 |
| D. Wetlands | 414.80 | NE,NO | NE,NO | | | | 414.80 |
| E. Settlements | 1,562.32 | NE,NO | NE,NO | | | | 1,562.32 |
| F. Other Land | 971.26 | NE,NO | NE,NO | | | | 971.26 |
| G. Other | 247.31 | NA,NE | NA,NE | | | | 247.31 |
| **6. Waste** | **16,518.65** | **7,725.06** | **3,382.03** | | | | **27,625.74** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 6,113.84 | | | | | 6,113.84 |
| B. Waste-water Handling | | 1,584.18 | 1,196.01 | | | | 2,780.20 |
| C. Waste Incineration | 15,888.12 | 12.60 | 2,173.23 | | | | 18,073.95 |
| D. Other | 630.53 | 14.44 | 12.79 | | | | 657.75 |
| **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 | 40.10 | 305.92 | | | | 33,917.44 |
| Aviation | 18,721.34 | 11.13 | 183.72 | | | | 18,916.19 |
| Marine | 14,850.08 | 28.97 | 122.20 | | | | 15,001.25 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **17,203.99** | | | | | | **17,203.99** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,320,491.52 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,239,702.33 |

(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.

## 9.13. Emissions and Removals in 2002

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2002
Submission 2009 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)** | **1,185,613.47** | **24,678.16** | **25,468.99** | **13,692.41** | **7,496.05** | **5,718.90** | **1,262,667.98** |
| **1. Energy** | **1,208,180.17** | **1,347.56** | **8,855.73** | | | | **1,218,383.46** |
| A. Fuel Combustion (Sectoral Approach) | 1,208,149.23 | 941.13 | 8,855.64 | | | | 1,217,945.99 |
| 1. Energy Industries | 381,371.44 | 44.72 | 1,889.28 | | | | 383,305.44 |
| 2. Manufacturing Industries and Construction | 374,801.46 | 333.32 | 2,479.98 | | | | 377,614.75 |
| 3. Transport | 256,577.32 | 282.27 | 4,110.70 | | | | 260,970.29 |
| 4. Other Sectors | 195,399.01 | 280.82 | 375.68 | | | | 196,055.51 |
| 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** | **52,577.51** | **141.64** | **1,238.77** | **13,692.41** | **7,496.05** | **5,718.90** | **80,865.29** |
| A. Mineral Products | 48,699.43 | NA,NO | NA,NO | | | | 48,699.43 |
| B. Chemical Industry | 3,657.13 | 125.00 | 1,238.77 | NA | NA | NA | 5,020.90 |
| C. Metal Production | 220.95 | 16.64 | NO | IE,NE | 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 | 1,003.80 | 8,470.34 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 7,235.79 | 6,471.29 | 3,591.80 | 17,298.89 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **334.05** | | | | **334.05** |
| **4. Agriculture** | | **15,780.27** | **11,584.10** | | | | **27,364.37** |
| A. Enteric Fermentation | | 7,306.98 | | | | | 7,306.98 |
| B. Manure Management | | 2,640.07 | 4,908.08 | | | | 7,548.15 |
| C. Rice Cultivation | | 5,729.23 | | | | | 5,729.23 |
| D. Agricultural Soils(3) | | NA | 6,598.55 | | | | 6,598.55 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 103.98 | 77.47 | | | | 181.45 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-91,087.07** | **20.53** | **18.15** | | | | **-91,048.39** |
| A. Forest Land | -93,495.88 | 20.53 | 2.08 | | | | -93,473.26 |
| B. Cropland | 390.39 | NE,NO | 16.07 | | | | 406.45 |
| C. Grassland | -465.58 | NE,NO | NE,NO | | | | -465.58 |
| D. Wetlands | 239.49 | NE,NO | NE,NO | | | | 239.49 |
| E. Settlements | 1,138.97 | NE,NO | NE,NO | | | | 1,138.97 |
| F. Other Land | 835.65 | NE,NO | NE,NO | | | | 835.65 |
| G. Other | 269.89 | NA,NE | NA,NE | | | | 269.89 |
| **6. Waste** | **15,942.87** | **7,388.15** | **3,438.18** | | | | **26,769.20** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 5,830.23 | | | | | 5,830.23 |
| B. Waste-water Handling | | 1,532.89 | 1,180.95 | | | | 2,713.84 |
| C. Waste Incineration | 15,365.82 | 11.24 | 2,245.00 | | | | 17,622.06 |
| D. Other | 577.05 | 13.80 | 12.23 | | | | 603.07 |
| **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 | 42.96 | 335.74 | | | | 37,107.63 |
| Aviation | 21,149.32 | 12.57 | 207.55 | | | | 21,369.44 |
| Marine | 15,579.61 | 30.39 | 128.19 | | | | 15,738.19 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **17,917.38** | | | | | | **17,917.38** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,353,716.37 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,262,667.98 |

(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.

## 9.14. Emissions and Removals in 2003

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2003
Submission 2009 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)** | **1,192,548.63** | **24,196.20** | **25,224.38** | **13,760.54** | **7,259.78** | **5,409.28** | **1,268,398.80** |
| **1. Energy** | **1,214,275.31** | **1,307.17** | **8,614.84** | | | | **1,224,197.31** |
| A. Fuel Combustion (Sectoral Approach) | 1,214,240.85 | 917.81 | 8,614.73 | | | | 1,223,773.39 |
| 1. Energy Industries | 395,393.31 | 45.17 | 1,939.33 | | | | 397,377.81 |
| 2. Manufacturing Industries and Construction | 375,765.15 | 356.53 | 2,484.47 | | | | 378,606.15 |
| 3. Transport | 254,503.21 | 270.75 | 3,833.24 | | | | 258,607.20 |
| 4. Other Sectors | 188,579.18 | 245.36 | 357.69 | | | | 189,182.23 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 34.46 | 389.36 | 0.11 | | | | 423.92 |
| 1. Solid Fuels | NE,NO | 93.86 | NE,NO | | | | 93.86 |
| 2. Oil and Natural Gas | 34.46 | 295.49 | 0.11 | | | | 330.06 |
| **2. Industrial Processes** | **52,215.50** | **133.88** | **1,259.55** | **13,760.54** | **7,259.78** | **5,409.28** | **80,038.52** |
| A. Mineral Products | 48,565.50 | NA,NO | NA,NO | | | | 48,565.50 |
| B. Chemical Industry | 3,408.43 | 117.38 | 1,259.55 | NA | NA | NA | 4,785.36 |
| C. Metal Production | 241.57 | 16.50 | NO | IE,NE | 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 | 965.56 | 7,390.66 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 8,301.04 | 6,278.97 | 3,318.19 | 17,898.20 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **320.83** | | | | **320.83** |
| **4. Agriculture** | | **15,643.91** | **11,510.07** | | | | **27,153.97** |
| A. Enteric Fermentation | | 7,211.54 | | | | | 7,211.54 |
| B. Manure Management | | 2,604.69 | 4,878.79 | | | | 7,483.48 |
| C. Rice Cultivation | | 5,725.83 | | | | | 5,725.83 |
| D. Agricultural Soils(3) | | NA | 6,556.56 | | | | 6,556.56 |
| E. Prescribed Burning of Savannas | | NE | NE | | | | NE |
| F. Field Burning of Agricultural Residues | | 101.85 | 74.72 | | | | 176.57 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-91,368.15** | **3.90** | **15.00** | | | | **-91,349.25** |
| A. Forest Land | -93,482.73 | 3.90 | 0.40 | | | | -93,478.44 |
| B. Cropland | 366.97 | NE,NO | 14.60 | | | | 381.57 |
| C. Grassland | -483.52 | NE,NO | NE,NO | | | | -483.52 |
| D. Wetlands | 188.24 | NE,NO | NE,NO | | | | 188.24 |
| E. Settlements | 1,076.03 | NE,NO | NE,NO | | | | 1,076.03 |
| F. Other Land | 720.50 | NE,NO | NE,NO | | | | 720.50 |
| G. Other | 246.37 | NA,NE | NA,NE | | | | 246.37 |
| **6. Waste** | **17,425.97** | **7,107.34** | **3,504.10** | | | | **28,037.41** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 5,590.69 | | | | | 5,590.69 |
| B. Waste-water Handling | | 1,492.10 | 1,187.68 | | | | 2,679.78 |
| C. Waste Incineration | 16,909.44 | 10.69 | 2,304.14 | | | | 19,224.27 |
| D. Other | 516.53 | 13.87 | 12.28 | | | | 542.68 |
| **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 | 45.52 | 340.95 | | | | 37,893.18 |
| Aviation | 20,387.64 | 12.12 | 200.08 | | | | 20,599.83 |
| Marine | 17,119.07 | 33.40 | 140.87 | | | | 17,293.34 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,296.55** | | | | | | **18,296.55** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,359,748.06 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,268,398.80 |

(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.

## 9.15. Emissions and Removals in 2004

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2004
Submission 2009 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)] | **1,190,898.87** | **23,817.73** | **25,300.68** | **10,551.07** | **7,547.62** | **5,314.40** | **1,263,430.38** |
| **1. Energy** | **1,214,568.62** | **1,281.45** | **8,336.40** | | | | **1,224,186.47** |
| A. Fuel Combustion (Sectoral Approach) | 1,214,533.63 | 908.48 | 8,336.29 | | | | 1,223,778.40 |
| 1. Energy Industries | 391,103.71 | 43.71 | 1,942.94 | | | | 393,090.36 |
| 2. Manufacturing Industries and Construction | 381,941.32 | 361.07 | 2,512.84 | | | | 384,815.23 |
| 3. Transport | 254,453.45 | 251.19 | 3,522.64 | | | | 258,227.28 |
| 4. Other Sectors | 187,035.15 | 252.52 | 357.87 | | | | 187,645.54 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 34.99 | 372.97 | 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** | **52,555.70** | **143.47** | **1,657.60** | **10,551.07** | **7,547.62** | **5,314.40** | **77,769.87** |
| A. Mineral Products | 48,838.58 | NA,NO | NA,NO | | | | 48,838.58 |
| B. Chemical Industry | 3,459.28 | 126.46 | 1,657.60 | NA | NA | NA | 5,243.34 |
| C. Metal Production | 257.84 | 17.01 | NO | IE,NE | 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 | 979.90 | 3,316.48 |
| F. Consumption of Halocarbons and $SF_6$ [(2)] | | | | 9,081.34 | 6,665.98 | 3,223.48 | 18,970.79 |
| G. Other | NO | NO | NO | NO | NO | NO | NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **297.54** | | | | **297.54** |
| **4. Agriculture** | | **15,539.14** | **11,450.19** | | | | **26,989.33** |
| A. Enteric Fermentation | | 7,130.82 | | | | | 7,130.82 |
| B. Manure Management | | 2,559.59 | 4,851.13 | | | | 7,410.72 |
| C. Rice Cultivation | | 5,747.41 | | | | | 5,747.41 |
| D. Agricultural Soils[(3)] | | NA | 6,525.44 | | | | 6,525.44 |
| E. Prescribed Burning of Savannas | | NO | NO | | | | NO |
| F. Field Burning of Agricultural Residues | | 101.33 | 73.63 | | | | 174.95 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry**[(1)] | **-91,613.03** | **12.12** | **13.33** | | | | **-91,587.58** |
| A. Forest Land | -93,459.11 | 12.12 | 1.23 | | | | -93,445.76 |
| B. Cropland | 304.92 | NE,NO | 12.10 | | | | 317.01 |
| C. Grassland | -530.04 | NE,NO | NE,NO | | | | -530.04 |
| D. Wetlands | 154.41 | NE,NO | NE,NO | | | | 154.41 |
| E. Settlements | 1,017.46 | NE,NO | NE,NO | | | | 1,017.46 |
| F. Other Land | 663.07 | NE,NO | NE,NO | | | | 663.07 |
| G. Other | 236.27 | NA,NE | NA,NE | | | | 236.27 |
| **6. Waste** | **15,387.58** | **6,841.55** | **3,545.61** | | | | **25,774.74** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 5,361.78 | | | | | 5,361.78 |
| B. Waste-water Handling | | 1,455.90 | 1,195.89 | | | | 2,651.79 |
| C. Waste Incineration | 14,880.88 | 10.31 | 2,337.71 | | | | 17,228.90 |
| D. Other | 506.70 | 13.56 | 12.01 | | | | 532.28 |
| **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 | 47.56 | 355.43 | | | | 39,516.11 |
| Aviation | 21,190.20 | 12.59 | 207.95 | | | | 21,410.75 |
| Marine | 17,922.92 | 34.97 | 147.47 | | | | 18,105.36 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **18,188.62** | | | | | | **18,188.62** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,355,017.96 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,263,430.38 |

(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.

## 9.16. Emissions and Removals in 2005

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2005
Submission 2009 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)** | **1,201,727.70** | **23,430.43** | **24,857.36** | **10,600.86** | **7,058.34** | **4,581.68** | **1,272,256.38** |
| **1. Energy** | **1,218,775.72** | **1,287.30** | **8,330.82** | | | | **1,228,393.84** |
| A. Fuel Combustion (Sectoral Approach) | 1,218,738.12 | 891.55 | 8,330.70 | | | | 1,227,960.38 |
| 1. Energy Industries | 406,196.01 | 42.71 | 1,981.90 | | | | 408,220.62 |
| 2. Manufacturing Industries and Construction | 375,515.88 | 357.61 | 2,770.91 | | | | 378,644.40 |
| 3. Transport | 249,534.32 | 238.01 | 3,221.15 | | | | 252,993.48 |
| 4. Other Sectors | 187,491.91 | 253.23 | 356.74 | | | | 188,101.88 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 37.60 | 395.74 | 0.12 | | | | 433.46 |
| 1. Solid Fuels | NE,NO | 73.56 | NE,NO | | | | 73.56 |
| 2. Oil and Natural Gas | 37.60 | 322.18 | 0.12 | | | | 359.90 |
| **2. Industrial Processes** | **53,857.98** | **133.78** | **1,299.94** | **10,600.86** | **7,058.34** | **4,581.68** | **77,532.58** |
| A. Mineral Products | 50,431.35 | NA,NO | NA,NO | | | | 50,431.35 |
| B. Chemical Industry | 3,184.71 | 116.89 | 1,299.94 | NA | NA | NA | 4,601.54 |
| C. Metal Production | 241.93 | 16.89 | NO | IE,NE | 14.80 | 1,114.29 | 1,387.91 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 816.01 | 837.49 | 789.03 | 2,442.53 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 9,784.85 | 6,206.05 | 2,678.36 | 18,669.26 |
| G. Other | NO | NO | NO | NA,NO | NO | NO | NA,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **266.41** | | | | **266.41** |
| **4. Agriculture** | | **15,476.55** | **11,355.32** | | | | **26,831.87** |
| A. Enteric Fermentation | | 7,087.06 | | | | | 7,087.06 |
| B. Manure Management | | 2,512.80 | 4,848.69 | | | | 7,361.49 |
| C. Rice Cultivation | | 5,774.68 | | | | | 5,774.68 |
| D. Agricultural Soils(3) | | NA | 6,433.45 | | | | 6,433.45 |
| E. Prescribed Burning of Savannas | | NO | NO | | | | NO |
| F. Field Burning of Agricultural Residues | | 102.01 | 73.18 | | | | 175.19 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-85,607.65** | **9.14** | **10.98** | | | | **-85,587.53** |
| A. Forest Land | -87,504.26 | 9.14 | 0.93 | | | | -87,494.19 |
| B. Cropland | 259.37 | NE,NO | 10.05 | | | | 269.42 |
| C. Grassland | -593.42 | NE,NO | NE,NO | | | | -593.42 |
| D. Wetlands | 142.11 | NE,NO | NE,NO | | | | 142.11 |
| E. Settlements | 1,260.56 | NE,NO | NE,NO | | | | 1,260.56 |
| F. Other Land | 596.73 | NE,NO | NE,NO | | | | 596.73 |
| G. Other | 231.25 | NA,NE | NA,NE | | | | 231.25 |
| **6. Waste** | **14,701.65** | **6,523.67** | **3,593.90** | | | | **24,819.22** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 5,093.60 | | | | | 5,093.60 |
| B. Waste-water Handling | | 1,405.96 | 1,168.64 | | | | 2,574.60 |
| C. Waste Incineration | 14,194.84 | 9.79 | 2,412.57 | | | | 16,617.19 |
| D. Other | 506.81 | 14.32 | 12.69 | | | | 533.82 |
| **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 | 52.15 | 375.86 | | | | 41,992.88 |
| Aviation | 21,336.33 | 12.68 | 209.39 | | | | 21,558.39 |
| Marine | 20,228.55 | 39.47 | 166.47 | | | | 20,434.49 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **21,743.30** | | | | | | **21,743.30** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,357,843.92 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,272,256.38 |

(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.

## 9.17. Emissions and Removals in 2006

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS (Sheet 1 of 1)**

Inventory 2006
Submission 2009 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)** | **1,188,441.82** | **23,039.47** | **24,748.42** | **11,623.37** | **7,385.00** | **5,147.13** | **1,260,385.21** |
| **1. Energy** | **1,201,570.04** | **1,325.17** | **8,089.20** | | | | **1,210,984.41** |
| A. Fuel Combustion (Sectoral Approach) | 1,201,534.16 | 916.66 | 8,089.08 | | | | 1,210,539.89 |
| 1. Energy Industries | 395,570.67 | 44.65 | 1,980.45 | | | | 397,595.77 |
| 2. Manufacturing Industries and Construction | 381,831.23 | 368.68 | 2,789.82 | | | | 384,989.73 |
| 3. Transport | 246,335.07 | 222.75 | 2,974.16 | | | | 249,531.98 |
| 4. Other Sectors | 177,797.18 | 280.57 | 344.65 | | | | 178,422.40 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 35.89 | 408.51 | 0.11 | | | | 444.51 |
| 1. Solid Fuels | NE,NO | 68.12 | NE,NO | | | | 68.12 |
| 2. Oil and Natural Gas | 35.89 | 340.40 | 0.11 | | | | 376.40 |
| **2. Industrial Processes** | **53,862.07** | **133.03** | **1,624.72** | **11,623.37** | **7,385.00** | **5,147.13** | **79,775.32** |
| A. Mineral Products | 50,463.61 | NA,NO | NA,NO | | | | 50,463.61 |
| B. Chemical Industry | 3,220.92 | 115.87 | 1,624.72 | NA | NA | NA | 4,961.51 |
| C. Metal Production | 177.55 | 17.16 | NO | IE,NE | 14.82 | 1,045.67 | 1,255.21 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 938.25 | 879.14 | 1,648.34 | 3,465.72 |
| F. Consumption of Halocarbons and $SF_6$ (2) | | | | 10,685.13 | 6,491.03 | 2,453.12 | 19,629.27 |
| G. Other | NO | NO | NO | NA,NO | NO | NO | NA,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **244.76** | | | | **244.76** |
| **4. Agriculture** | | **15,398.99** | **11,310.80** | | | | **26,709.79** |
| A. Enteric Fermentation | | 7,105.06 | | | | | 7,105.06 |
| B. Manure Management | | 2,448.35 | 4,854.39 | | | | 7,302.74 |
| C. Rice Cultivation | | 5,742.87 | | | | | 5,742.87 |
| D. Agricultural Soils(3) | | NA | 6,381.59 | | | | 6,381.59 |
| E. Prescribed Burning of Savannas | | NO | NO | | | | NO |
| F. Field Burning of Agricultural Residues | | 102.71 | 74.82 | | | | 177.54 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry(1)** | **-81,734.94** | **2.44** | **9.11** | | | | **-81,723.39** |
| A. Forest Land | -83,392.26 | 2.44 | 0.25 | | | | -83,389.58 |
| B. Cropland | 256.73 | NE,NO | 8.87 | | | | 265.60 |
| C. Grassland | -620.84 | NE,NO | NE,NO | | | | -620.84 |
| D. Wetlands | 186.88 | NE,NO | NE,NO | | | | 186.88 |
| E. Settlements | 924.42 | NE,NO | NE,NO | | | | 924.42 |
| F. Other Land | 679.80 | NE,NO | NE,NO | | | | 679.80 |
| G. Other | 230.34 | NA,NE | NA,NE | | | | 230.34 |
| **6. Waste** | **14,744.65** | **6,179.84** | **3,469.83** | | | | **24,394.31** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 4,784.19 | | | | | 4,784.19 |
| B. Waste-water Handling | | 1,369.21 | 1,159.00 | | | | 2,528.21 |
| C. Waste Incineration | 14,222.29 | 9.81 | 2,296.09 | | | | 16,528.18 |
| D. Other | 522.36 | 16.64 | 14.74 | | | | 553.73 |
| **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 | 48.99 | 352.50 | | | | 39,393.41 |
| Aviation | 19,964.61 | 11.87 | 195.93 | | | | 20,172.40 |
| Marine | 19,027.31 | 37.12 | 156.58 | | | | 19,221.01 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **21,978.52** | | | | | | **21,978.52** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,342,108.59 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,260,385.21 |

(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.

## 9.18. Emissions and Removals in 2007

**SUMMARY 2 SUMMARY REPORT FOR $CO_2$ EQUIVALENT EMISSIONS**
**(Sheet 1 of 1)**

Inventory 2007
Submission 2009 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)]** | **1,222,418.57** | **22,605.89** | **23,799.85** | **13,210.14** | **6,483.42** | **4,385.01** | **1,292,902.88** |
| **1. Energy** | **1,235,264.94** | **1,285.72** | **7,942.60** | | | | **1,244,493.26** |
| A. Fuel Combustion (Sectoral Approach) | 1,235,227.42 | 869.24 | 7,942.48 | | | | 1,244,039.14 |
| 1. Energy Industries | 448,564.29 | 50.20 | 2,064.45 | | | | 450,678.94 |
| 2. Manufacturing Industries and Construction | 381,040.08 | 369.24 | 2,778.45 | | | | 384,187.77 |
| 3. Transport | 241,587.08 | 209.22 | 2,783.33 | | | | 244,579.63 |
| 4. Other Sectors | 164,035.96 | 240.58 | 316.25 | | | | 164,592.80 |
| 5. Other | NO | NO | NO | | | | NO |
| B. Fugitive Emissions from Fuels | 37.53 | 416.48 | 0.12 | | | | 454.12 |
| 1. Solid Fuels | NE,NO | 51.48 | NE,NO | | | | 51.48 |
| 2. Oil and Natural Gas | 37.53 | 365.00 | 0.12 | | | | 402.65 |
| **2. Industrial Processes** | **53,729.84** | **133.81** | **860.18** | **13,210.14** | **6,483.42** | **4,385.01** | **78,802.40** |
| A. Mineral Products | 50,218.95 | NA,NO | NA,NO | | | | 50,218.95 |
| B. Chemical Industry | 3,298.87 | 116.51 | 860.18 | NA | NA | NA | 4,275.56 |
| C. Metal Production | 212.02 | 17.30 | NO | IE,NE | 14.69 | 996.13 | 1,240.14 |
| D. Other Production | IE | | | | | | IE |
| E. Production of Halocarbons and $SF_6$ | | | | 497.61 | 783.02 | 1,270.43 | 2,551.06 |
| F. Consumption of Halocarbons and $SF_6$ [(2)] | | | | 12,712.54 | 5,685.71 | 2,118.45 | 20,516.69 |
| G. Other | NO | NO | NO | NA,NO | NO | NO | NA,NO |
| **3. Solvent and Other Product Use** | **NA,NE** | | **244.76** | | | | **244.76** |
| **4. Agriculture** | | **15,271.86** | **11,274.42** | | | | **26,546.28** |
| A. Enteric Fermentation | | 7,120.61 | | | | | 7,120.61 |
| B. Manure Management | | 2,394.07 | 4,860.72 | | | | 7,254.79 |
| C. Rice Cultivation | | 5,654.25 | | | | | 5,654.25 |
| D. Agricultural Soils[(3)] | | NA | 6,337.41 | | | | 6,337.41 |
| E. Prescribed Burning of Savannas | | NO | NO | | | | NO |
| F. Field Burning of Agricultural Residues | | 102.93 | 76.29 | | | | 179.23 |
| G. Other | | NO | NO | | | | NO |
| **5. Land Use, Land-Use Change and Forestry[(1)]** | **-81,362.60** | **1.91** | **8.05** | | | | **-81,352.64** |
| A. Forest Land | -82,867.02 | 1.91 | 0.19 | | | | -82,864.91 |
| B. Cropland | 265.44 | NE,NO | 7.86 | | | | 273.30 |
| C. Grassland | -614.90 | NE,NO | NE,NO | | | | -614.90 |
| D. Wetlands | 167.06 | NE,NO | NE,NO | | | | 167.06 |
| E. Settlements | 848.78 | NE,NO | NE,NO | | | | 848.78 |
| F. Other Land | 607.70 | NE,NO | NE,NO | | | | 607.70 |
| G. Other | 230.34 | NA,NE | NA,NE | | | | 230.34 |
| **6. Waste** | **14,786.39** | **5,912.58** | **3,469.83** | | | | **24,168.81** |
| A. Solid Waste Disposal on Land | NA,NE,NO | 4,516.93 | | | | | 4,516.93 |
| B. Waste-water Handling | | 1,369.21 | 1,159.00 | | | | 2,528.21 |
| C. Waste Incineration | 14,226.64 | 9.81 | 2,296.09 | | | | 16,532.54 |
| D. Other | 559.75 | 16.64 | 14.74 | | | | 591.13 |
| **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** | 37,303.01 | 47.96 | 336.41 | | | | 37,687.38 |
| Aviation | 18,358.58 | 10.91 | 180.16 | | | | 18,549.66 |
| Marine | 18,944.42 | 37.05 | 156.25 | | | | 19,137.72 |
| **Multilateral Operations** | **NO** | **NO** | **NO** | | | | **NO** |
| **$CO_2$ Emissions from Biomass** | **22,957.60** | | | | | | **22,957.60** |

| | |
|---|---|
| Total $CO_2$ Equivalent Emissions without Land Use, Land-Use Change and Forestry | 1,374,255.51 |
| Total $CO_2$ Equivalent Emissions with Land Use, Land-Use Change and Forestry | 1,292,902.88 |

(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.