The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Overview of IPCC Guidelines

7 September, 2010

Chief Advisor of JICA Expert Team
Masahiko FUJIMOTO

Training Program of GHG Inventory (1)

Topic 1: Overview of **IPCC Guidelines**

Topic 2: Introduction of **GHG inventory of Japan and Thailand**

Topic 3: Overview of **energy sector** including **transportation**, example of Thailand and Japan

Topic 4: Overview of **industrial process sector**, example of Thailand and Japan

Topic 5: Overview of **agriculture, land-use change sector**, example of Thailand and Japan

Training Program of GHG Inventory (2)

Topic 6: Overview of **waste management** sector, example of Thailand and Japan

Topic 7: Overview of **QA/QC** of IPCC Guidelines and example of QA/QC measures taken in Japan

Topic 8: Analysis of **key categories and assessment of uncertainties**, example from Japanese cases

Topic 9: **Exercise**: Calculation of emission of energy sector in Thai inventory

Topic 10: **Exercise**: Calculation of key category and uncertainty in Thai inventory

Contents of today's training program

1. Why does Thailand have to make the GHG inventories?
2. How are the GHG inventories made?
3. What are the guidelines for GHG inventory preparation?

Questions!

- Q1: Why Thailand needs to provide GHG inventory?

Reporting under UNFCCC

- UNFCCC Article 4 1. and Article 12
  - **All Parties** develop, periodically update, publish and make available to the Conference of the Parties a **national inventory**, a general description of steps and any other information.
- UNFCCC Article 4 2(c)
  - Calculations should take into account the best available scientific knowledge.
  - COP shall consider and agree on methodologies at its first session and review them regularly thereafter.

Requirement in Copenhagen Accord

- Draft decision -/COP15 (Copenhagen Accord) 5.
  - Mitigation actions subsequently taken and envisaged by **Non-Annex I Parties**, including **national inventory reports**, shall be communicated though **national communication** consistent with Article 12.1(b) every two years on the basis of guidelines adopted by the Conference of the Parties.

Useful in developing rational policy and its monitoring

- Inventories are very useful for the rational policy development for Low Carbon Society.
- Inventories can be used
  - to identify the major sectors where abatement will have a real impact.
  - To predict and compare impacts of various policies.
  - To choose cost-effective options.
- Inventories are very useful to monitor the impacts of mitigation policies and measures.

Source: National GHG Inventory Development - Background and Key Factors for Success
Mr. Kiyoto Tanabe

Questions!

- Q2: How are the GHG inventories made?

How are the GHG inventories made?

- GHG emission is **estimated based on statistical data**, etc.;
- the concentration of GHG in the atmosphere is not measured directly.

Emissions = Activity Data x Emission Factor x Global Warming Potential

Greenhouse Gases related to each Sector

	CO_2	CH_4	N_2O	HFCs, etc
Energy	Fuel Combustion	Fuel Combustion Fugitive emissions from fuels	Fuel Combustion	
Industrial Process	Cement Production, etc	Chemical Industry, etc	Chemical Industry, etc	Semiconductors, Solvent, Refrigerant, etc
Agriculture, Forestry and Other Land Use		Intestinal Fermentation, Rice cultivation, Manure management, etc	Agricultural soils, Manure management, etc	
Waste	Waste incineration	Landfill, Wastewater treatment, Waste incineration, etc	Landfill, Wastewater treatment, Waste incineration, etc	

Activity Data

- Activity Data:

  Data related to activities resulting in GHG emissions or removals

  For example; Energy use (coal, heavy oil, diesel, gasoline, natural gas) in sector, Number of cattle, Land area, Municipal solid waste amount, etc

Emissions = **Activity Data** x Emission Factor x Global Warming Potential

Approaches to Activity Data Collection

1) Gathering existing data
   - National and international statistics agencies
   - Sectoral experts, national experts, researchers of universities
   - Reference libraries
   - Web search for organisations & specialists

2) Checking and Screening collected data

3) If data not available, methods like splicing/ surrogates/interpolation/extrapolation are used.

Emission Factor

- Emission Factor:

  - A coefficient that quantifies GHG emissions or removals per unit activity.

  - Emission factors are based on measurement data, or average of representative emission rates under a given set of operating conditions

Emissions = Activity Data x **Emission Factor** x Global Warming Potential

Methods of setting emission factor

- Actual measurement in factories etc.
- Results of research (set from the actual measurements etc.)
- Default values of IPCC Guideline
- Calculation from the scientific theoretical value (CO_2 from fuel combustion)

Other Possible Data Sources (from 2006 IPCC GL p 2.13)

- EMEP/CORINAIR Emission Inventory Guidebook
- International Emission Factor Database: USEPA
- Country-specific data from international or national peer reviewed journals
- National testing facilities
- Emission regulating authority records and papers, or pollution release and transfer registries
- Industry, technical and trade paper
- Other specific studies, census, survey, measurement and monitoring data
- International Emission Factor Database: OECD
- Emission factors or other estimation parameters for other countries

Outline of EFDB

- Supporting Material: The EFDB complements IPCC Guideline.
- It is designed as a platform for experts and researchers to provide new emission factors or other parameters to a worldwide audience of potential end users
- The EFDB invites experts and researchers all over the world to populate the EFDB with their data.
- The criteria for inclusion of data
  - Robustness: The value would be unlikely to change.
  - Applicability: An emission factor can only be applicable if the source and its mix of technology are clear.
  - Documentation: Access information to the original technical reference is provided to evaluate the robustness and applicable.

IPCC Emission Factor Database

URL: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Global Warming Potential

- Global Warming Potential:

  <in the first Commitment Period>
  - CO_2 1
  - CH_4 21
  - N_2O 310
  - HFCs 1300 etc.
  - PFCs 6500 etc.
  - SF6 23900

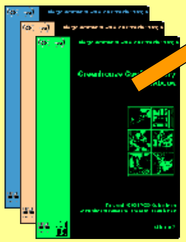
Emissions = Activity Data x Emission Factor x Global Warming Potential

Questions!

- Q: What are the guidelines for GHG inventory preparation?

Process of revision and evolution of IPCC Inventory Guideline

- Used in the 1st commitment period
  - Revised 1996
  - IPCC Guidelines

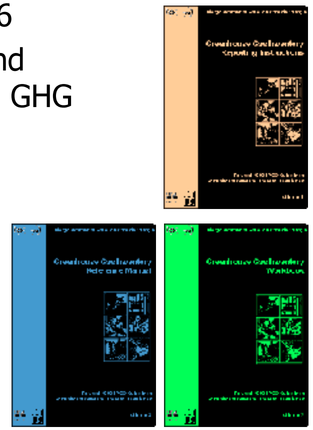


GPG2000 (except LULUCF) GPG2003 (LULUCF)

- Used in the 2nd commitment period
  - 2006 IPCC Guidelines

Revised 1996 IPCC Guidelines

- First version in 1995, Revised in 1996
  - Nationally approved calculation and reporting methodology related to GHG emission and removal
  - 6 sectors: 1) Energy, 2) Industrial process, 3) Solvent and other product use, 4) Agriculture, 5) Land use change and forestry, 6) Waste
  - Target gases: CO_2, CH_4, N_2O, HFCs, PFCs, SF6, NOX, CO, NMVOC, SO_2



GPG (Good Practice Guidance)

- Good Practice related to GHG inventory preparation in each country, which is useful to;
  - Avoid over- or under-estimation to a maximum extent
  - Decrease uncertainty in a practical extent
- GPG2000: except Land use, Land use change and forestry
- GPG2003-LULUCF: Land use, Land use change and forestry

GPG2000

GPG2003-LULUCF

2006 IPCC Guidelines

- Guidelines have evolved from 1996 to 2006, which have developed and improved as knowledge and experience increased.
- The same basic methodological approaches are used from 1996 Guidelines, through GPG 2000 & GPG LULUCF to 2006 Guidelines

Outline of Modification in 2006 IPCC Guidelines (1)

- Consolidated to 4 sectors: Energy, IPPU (Industrial Processes and Product Use), AFOLU (Agriculture, Forestry and Other Land Use), Waste
- More greenhouse gases: **NF_3, SF_5CF_3**
- Energy:
  - Improved defaults for fossil fuel combustion
  - Some additional categories; ex. CCS, Road Transport Urea Catalysts, uncontrolled burning of coal dumps,abandoned coal mines
- Waste:
  - Significant improvement to default method for landfills
  - Tier 1 FOD method to estimate CH_4 from SWDSs
  - Open burning
- All estimates are now of actual annual emissions ("potential" emissions not needed)

Outline of Modification in 2006 IPCC Guidelines (2)

- IPPU:
  - In IPPU sector, recently there has been rapid expansion of knowledge about sources and gases, so there are many new categories.
  - Some additional categories; ex. Production of Titanium Dioxide, Lead Production, Production of PV cells and LCD etc.
  - Non-energy uses of Fossil Fuel was demarcated with "Energy" sector
  - Actual emission of F gases is used as Tier 1
- AFOLU:
  - 2006 IPCC Guidelines integrate "Agriculture" and "Land Use, Land Use Change and Forestry" sector
  - Managed land is used as a proxy for identifying anthropogenic emissions by sources and removals by sinks.
  - CH_4 from managed flooded land was added in "Appendix – Basis of future methodological development"

Requirements under UNFCCC

- 1996 Guidelines (GPG2000, GPG2003-LULUCF)
  - Annex I Parties "shall" use 1996GLs and GPG2000, 2003-LULUCF
  - Non-Annex I Parties:
    - "should" use 1996GLs [Dec 17/CP.8]
    - "are encouraged to" use GPG2000 and GPG2003-LULUCF [Dec 13/CP.9]
- 2006 Guidelines
  - Not yet approved by UNFCCC for use as a whole
  - Nevertheless, 2006GLs may assist Parties in fulfilling their inventory reporting requirements under the UNFCCC

Source: National GHG Inventory Development - Background and Key Factors for Success
Mr. Kiyoto Tanabe

Relevance of 2006 IPCC Guidelines

- Individual methods in 2006GLs can be used within the 1996/UNFCCC reporting guidelines
  - The 2006GLs are:
    - An evolutionary development
    - Authors' best methodologies available (accepted by IPCC)
    - For the use of all countries

Source: National GHG Inventory Development - Background and Key Factors for Success
Mr. Kiyoto Tanabe

The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Introduction of GHG Inventories of Japan and Thailand

14, September, 2010

Deputy chief advisor of JICA Expert Team

Kazuhito YAMADA

Today's Agenda

- Why do we need GHG inventories? - confirmation -
- GHG Emission/Removal Sectors
- What is the most important GHG Inventory Work?
- GHG Emission trend:
  Japan, Germany, New Zealand, and Canada
- National System of Japan to develop GHG Inventory
- Characteristics of Japanese GHG Inventory:
  - Transport, Paddy field, and Waste
- ***Introduction of GHG Inventories of Thailand***
- Discussions

Why do we need GHG inventories? - confirmation -

- GHGs released by human activities enhance the radiative forcing of the climate system;
- Social and economic systems of human beings are affected by climate change such as temperature rise, sea-level rise, and precipitation pattern changes;
- Therefore, mitigation/adaptation measures of climate change are essential for human beings to survive;
- In order to mitigate anthropogenic GHG emissions at a national level, we need to know the following facts:
  - How much GHGs are emitted in each sector, and in total?
  - Which are the key sectors to reduce GHG emissions?

GHG Emission/Removal Sectors

- Energy
- Industrial processes
- Solvent and other product use

→ Industrial Processes and Product Use (IPPU)

- Agriculture
- Land-use Change and forestry
- Waste
- Other

→ Agriculture, Forestry and Other Land Use (AFOLU)

Source: Revised from Tanabe (2010)

What is the most important GHG Inventory Work?

- ***Data collection and methodology choice***
- Uncertainty assessment
- Identification of key categories
- Quality assurance and quality control
- Verification
- Ensuring time series consistency

I think this is the most important work!

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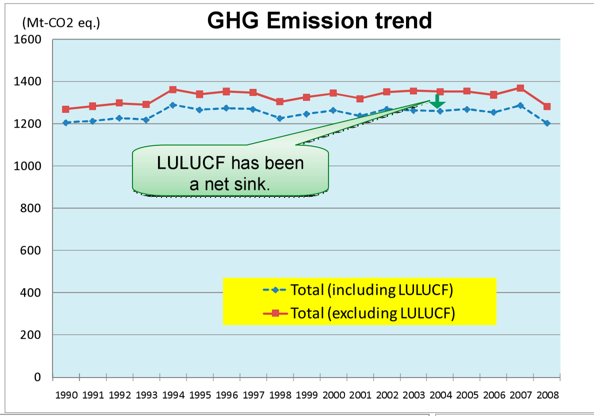


Japan

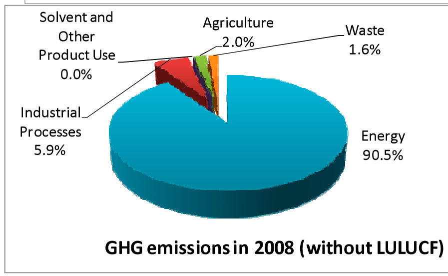
Emission trend: Increasing
(1.0% higher in 2008 than in 1990 [without LULUCF]
= 1.6% higher than KP Base Year)

LUCF: constantly sink

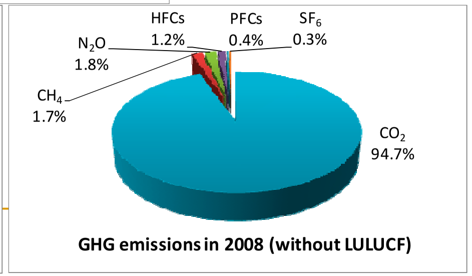
90.5% from Energy

94.7% of total GHG is CO_2
(89.9% = CO_2 from Energy)

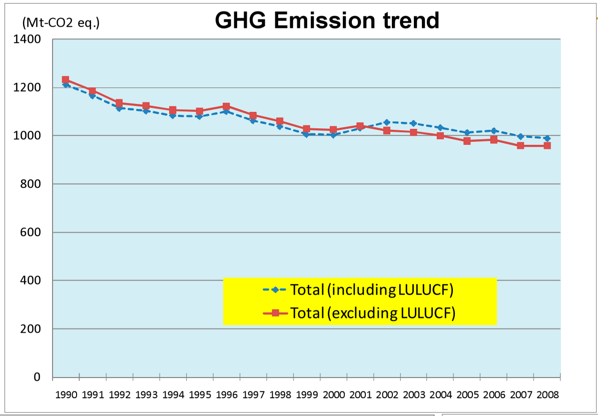
Source: Tanabe (2010)



GHG emissions in 2008 (without LULUCF)



GHG emissions in 2008 (without LULUCF)



Germany

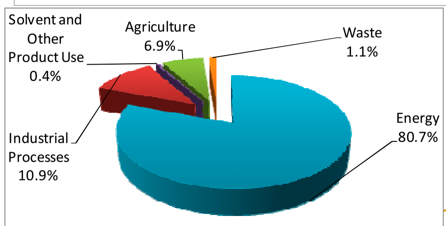
Emission trend: Decreasing
(22.2% lower in 2008 than in 1990 [without LULUCF]
= 22.3% lower than KP Base Year)

LUCF: sink in 1990-2001
source in 2002-2008

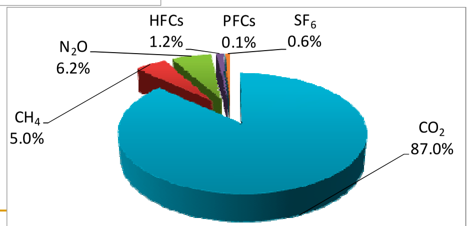
80.7% from Energy
10.9% from Industrial P.

87.0% of total GHG is CO_2
(78.5% = CO_2 from Energy)

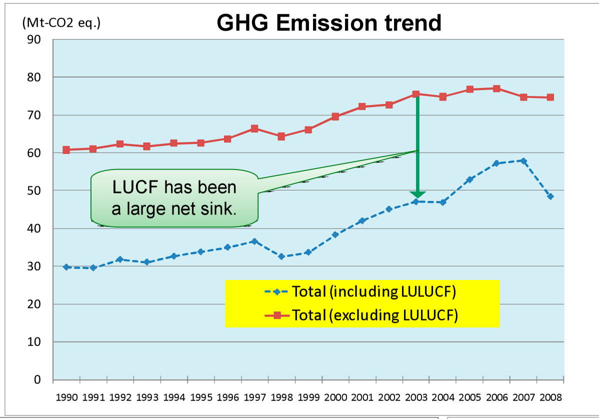
Source: Tanabe (2010)



GHG emissions in 2008 (without LULUCF)



GHG emissions in 2008 (without LULUCF)



New Zealand

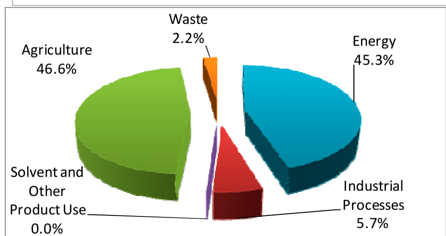
Emission trend: Increasing
(22.8% higher in 2008 than in 1990 [without LULUCF]
= 20.6% higher than KP Base Year)

LUCF: constantly large sink

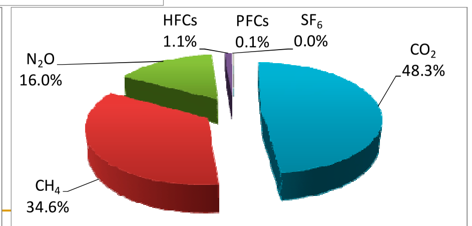
46.6% from Agriculture

34.6% of total GHG is CH_4
(30.3% = CH_4 from enteric fermentation (livestock))

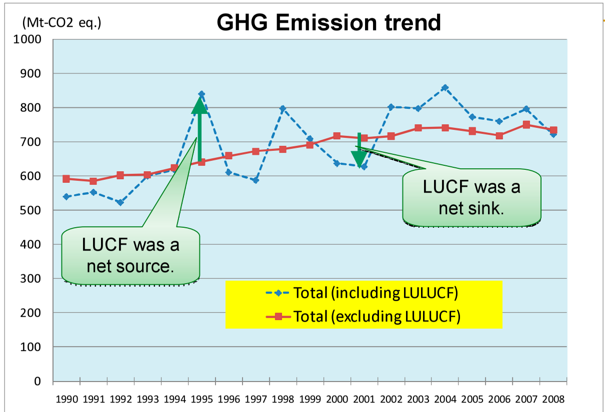
Source: Tanabe (2010)



GHG emissions in 2008 (without LULUCF)



GHG emissions in 2008 (without LULUCF)



Canada

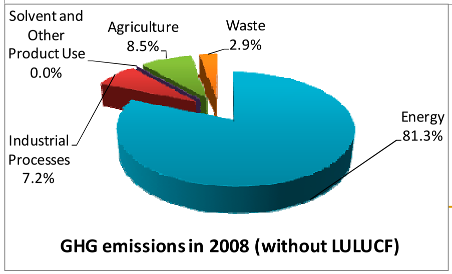
Emission trend: Increasing (24.1% higher in 2008 than in 1990 [without LULUCF] = 23.6% higher than KP Base Year)

LUCF: notably fluctuated year by year

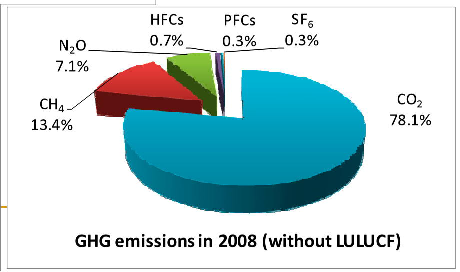
81.3% from Energy
8.5% from Agriculture

78.1% of total GHG is CO_2 (72.8% = CO_2 from Energy)

Source: Tanabe (2010)

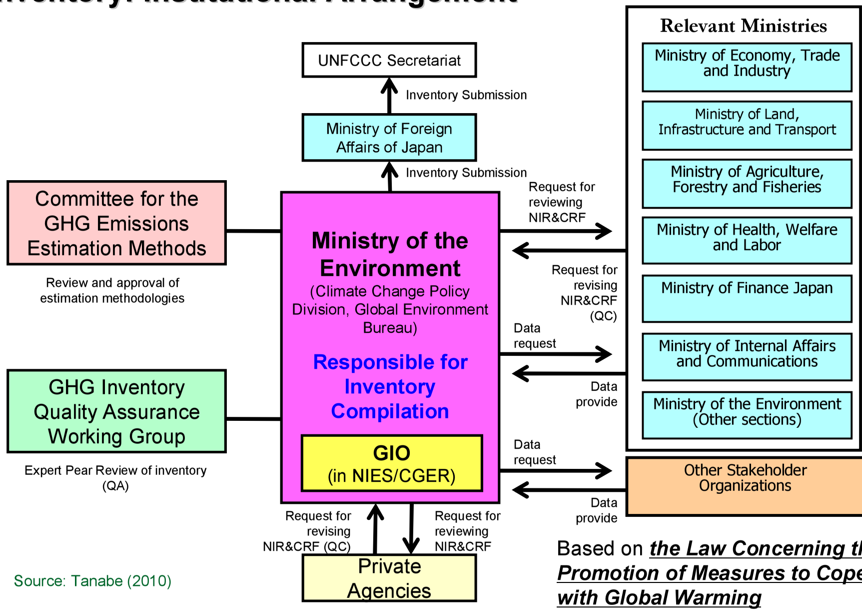


GHG emissions in 2008 (without LULUCF)



GHG emissions in 2008 (without LULUCF)

National System of Japan to develop GHG Inventory: Institutional Arrangement



Source: Tanabe (2010)

Based on ***the Law Concerning the Promotion of Measures to Cope with Global Warming***

Characteristics of Japanese GHG Inventory: Transport

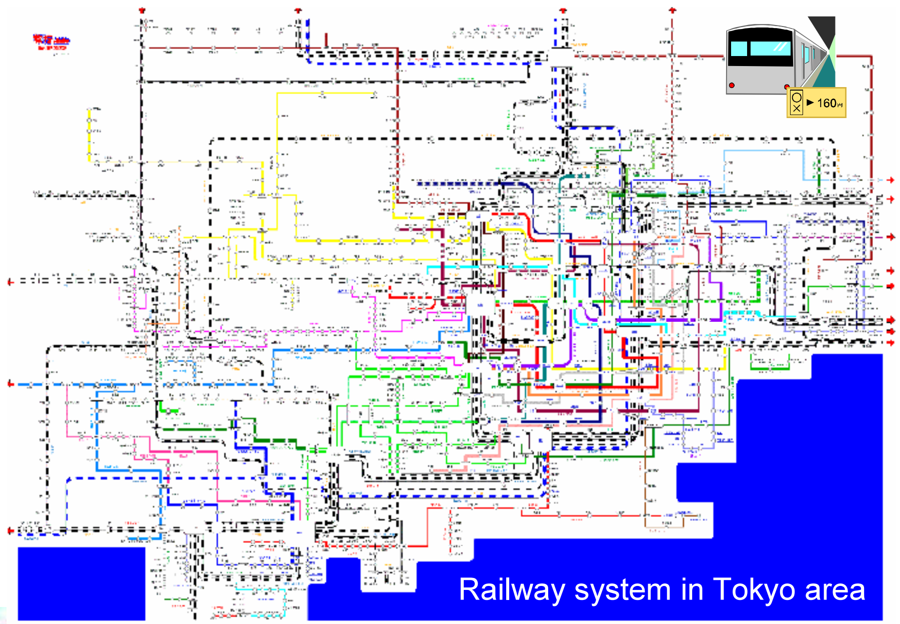
Introduction of Japanese Transport sector

- Main emitters: Civil Aviation, Road Transportation, Railways, and Navigation;
- The sector emitted 20.1% (228 mil. t-CO_2) of total GHG emission(2008).
- There are good public railway systems like 'SHINKANSEN'.

Characteristics of the sector (2008)

- Road Transportation is the biggest emitter (90.1%) in the sector;

- Railways emitted only 0.3% of the sector's GHG emission;
- Civil Aviation and Navigation emitted 9.6% of the sector's GHG emission.



Characteristics of Japanese GHG Inventory: Transport

Methodology adopted by Japan

- CO_2:

  Emission Factors (original data and IPCC2006) × Activity data (= 'General Energy Statistics')

  *The statistics has categories related to 'Transport Sector' such as 'Civil Aviation', 'Road Transportation', 'Railways' and 'Navigation'.

- CH_4, N_2O (Road Transportation):

  Emissions have been calculated distance travel per type of vehicle by emission factors using the Tier 3 method, in accordance with the GPG (2000). The country-specific emission factors (Japan Automobile Manufacturers Association data) 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 MLIT's Statistical Yearbook of Motor Vehicle Transport.

Emission factors for CH4 and N2O

The country-specific emission factors (CH4)

Fuel	Vehicle Type	Unit	2007	2008
Gasoline	Light Vehicle	gCH_4/km	0.006	0.006
	Passenger Vehicle	gCH_4/km	0.010	0.009
	Light Cargo Truck	gCH_4/km	0.010	0.009
	Small Cargo Truck	gCH_4/km	0.012	0.011
	Regular Cargo Truck	gCH_4/km	0.035	0.035
	Bus	gCH_4/km	0.035	0.035
	Special Vehicle	gCH_4/km	0.035	0.035
Diesel	Passenger Vehicle	gCH_4/km	0.013	0.013
	Small Cargo Truck	gCH_4/km	0.009	0.008
	Regular Cargo Truck	gCH_4/km	0.013	0.013
	Bus	gCH_4/km	0.017	0.017
	Special Vehicle	gCH_4/km	0.013	0.013

Emission factors for CH4 and N2O

How do they decided the emission factor?

- 10.15 mode provided by Japan Automobile Manufacturers Association
  - Measuring the emissions by 10.15 mode chosen as a running pattern of the average in the city in Japan under conditions, such as a certain specific temperature and humidity
- IPCC default value, GPG2000 data
- Actual measuring data

Activity data of the vehicle

The activity data: Distance traveled per type of vehicle

vehicle type	fuel type	Unit	2007	2008
Light vehicle	Gasolin	10^6 vehicles km	116,442	121,327
Passenger vehicle	Gasolin	10^6 vehicles km	363,707	351,943
	Diesel Oil	10^6 vehicles km	21,445	17,692
	LPG	10^6 vehicles km	13,427	12,864
Bus	Gasolin	10^6 vehicles km	69	73
	Diesel Oil	10^6 vehicles km	6,658	6,503
Light cargo truck	Gasolin	10^6 vehicles km	73,382	73,312
Small cargo truck + Cargo passenger truck	Gasolin	10^6 vehicles km	27,051	26,345
	Diesel Oil	10^6 vehicles km	38,064	36,295
Regular cargo truck	Gasolin	10^6 vehicles km	993	1,059
	Diesel Oil	10^6 vehicles km	80,516	77,887
Special vehicle	Gasolin	10^6 vehicles km	1,690	1,726
	Diesel Oil	10^6 vehicles km	20,185	19,851

Activity data of the vehicle

How do they decided the activity data?

- the proportion of running mileage for each fuel, which was calculated from fuel consumption and fuel efficiency
- the running distance for each category of vehicle given in the Statistical data (published by Ministry of Land, Infrastructure, Transport and Tourism)

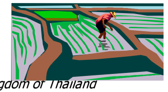
Characteristics of Japanese GHG Inventory: Paddy field

Introduction of Japanese paddy field

- Paddy field: 1,621,000 ha (2008), 4.3% of total area
  GHG emission: 5.6 million t-CO_2/y (0.4%)

Characteristics of Japanese paddy field

- Intermittently and continuously flooded paddy fields are targeted in this category. In Japan, Rice cultivation is practiced mainly on intermittently flooded paddy field.
- 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.



Characteristics of Japanese GHG Inventory: Paddy field

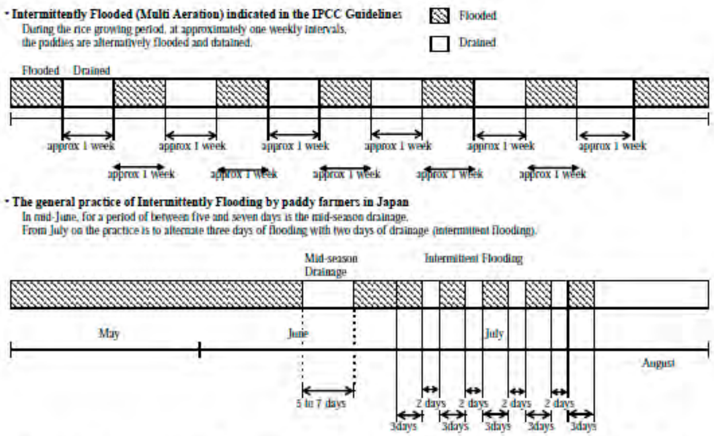


Figure 6-3 Comparison of water management regime in Japan and intermittent flooding (single aeration) indicated in the *IPCC Guidelines*

Characteristics of Japanese GHG Inventory: Paddy field

Methodology adopted by Japan

- CH_4, N_2O

CH_4 emission from intermittently flooded paddy fields (single aeration) (kg-CH_4) = Σ (EF for organic matter management method n for soil type m [kg-CH_4/m_2] × Area of paddy fields [m_2] × % of intermittently flooded paddy field × % of soil type m × % of organic matter management method n)

Table 6-25 Methane emission factor for intermittently flooded paddy fields (single aeration)

Type of soil	Straw amendment [gCH_4/m^2/year]	Various compost amendment [gCH_4/m^2/year]	No-amendment [gCH_4/m^2/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)

Characteristics of Japanese GHG Inventory: Waste

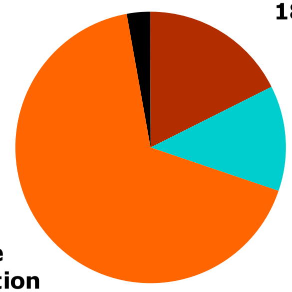
Introduction of Japanese waste

- In Japan, annual waste generation is amounted to around 600 Mt-CO_2/y and it has hardly changed since FY 1990.
- Waste of biogenic-origin, waste of fossil-origin, and metal and nonmetallic mineral wastes accounted respectively for 54%, 3% and 43% of total amount of waste.

Characteristics of Japanese waste

- In Japan, waste disposed of has been reduced in volume primarily by incineration.
- GHG emissions from waste incineration were 1,339,800 t-CO_2 and accounted for 1.0% of the national total emissions.

Characteristics of Japanese GHG Inventory: Waste



Characteristics of Japanese GHG Inventory: Waste

Methodology adopted by Japan

- CO_2 from municipal solid waste incinerated at facilities with energy recovery:

$E = EF \times A \times R$

E : Emission of CO_2 from the incineration of various types of waste (kg CO_2)

EF : Emission factor for the incineration of various types of waste (dry basis) (kg CO_2/t),

EF (dry basis) = 1000 [kg] × Carbon content × efficiency of combustion × 44/12

Examples of carbon content: plastics = 75.1%, synthetic textile = 63.0%

A: Volume of each type of waste incinerated (dry basis) (t)

R: % of municipal solid waste incinerated at facilities with energy recovery

Introduction of GHG Inventories of Thailand

Thank you very much for the contribution of

Ms. Wsinee Cheunban (Note-san)!!

Discussions

How to address the following major issues:

1. Lack of data
2. Inconsistency of data
3. Confidentiality of data
4. Incompleteness of data
5. Inconsecutiveness of data

Practice
Calculation : CO_2 emission From Crude Oil in Thailand (2008 IEA)

Calculation CO_2 emission

1.Energy Consumption

- A. Consumption
  (Mass, Volume or Energy unit)
- B. Conversion Factor (TJ/unit)
- C. Consumption (TJ)

2.CO_2 emission

- D. CO_2 Emission Factor (kg CO_2/TJ)
- E. CO_2 Emissions ($GgCO_2$)

1. Energy Consumption

Energy Consumption

- C=A X B

- A. Consumption
  (Mass, Volume or Energy unit)
- B. Conversion Factor (TJ/unit)
  (2006 IPCC Guideline default value)
- C. Consumption (TJ)

A. Consumption

- A. Consumption (Crude Oil)
(Mass, Volume or Energy unit)
- Final consumption :2,888 (1000tonnes)

(Source: P.Ⅱ.409, ENERGY STATICS OF NON-OECD COUNTRIES (2010Edition), IEA)

B. Conversion Factor

- B. Conversion Factor (TJ/unit) (Crude Oil)
- Net calorific Value : 42.3(TJ/Gg)

(Note: unit 1Gg=1000tonnes)

(Source: Table1.2, P.1.18, Chap.1 Volume 2: Energy, 2006 IPCC Guidelines)

C. Consumption

- C. Consumption (TJ) (Crude Oil)

C=A X B=2,888 X 42.3

=122,162.4 (TJ)

2. CO_2 Emission

CO_2 Emission

- $E=C \times D / 10^6$

- C. Energy Consumption (TJ)
- D. CO_2 Emission Factor (kg CO_2/TJ)
- E. CO_2 Emissions ($GgCO_2$)

D. CO_2 Emission Factor

- D. Effective CO_2 emission factor (Crude Oil)
- : 73,300 (kg/TJ)

(Source: Table1.4, P.1.23, Chap.1 Volume 2: Energy, 2006 IPCC Guidelines)

E. CO_2 Emissions

- E. CO_2 Emission ($GgCO_2$) (Crude Oil)

$E=C \times D / 10^6 = 122{,}162.4 \times 73{,}300 / 10^6$

$= 8{,}954.5$ ($GgCO_2$)

Thank you!

Tier1 Method

- Tier1 : Energy (Fuel) Consumption =

  "National Energy Statistics"

  x "Emission Factor"

What is TJ??

- TJ =1, 000, 000, 000, 000J

J is a standard unit of heat energy.
1Cal equals the heat energy to make 1g pure water from 14.5℃ to 15.5℃
1Cal = 4.1855J

What is Net calorific value?

- **Quantity of heat liberated by the complete combustion of a unit of fuel with evaporative latent heat.**
- **For coal and oil, the difference between net calorific values (NCVs) and gross calorific values (GCVs) is approximately 5%. In Japanese Energy Statistics, We use GCVs.**
- **For most natural gas and manufactured gases, the difference is approximately 9-10%.**

The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Overview of Energy Sector

14 September, 2010

GHG Inventory
Fumihiko KUWAHARA

Contents of "Energy Sector" Training Program

1. Introduction of GHG Inventory

- At first I have a common comment of the development of GHG inventories.
- In order to promote the development of high quality national greenhouse gas inventories, a collection of methodological principles, tasks and procedures were defined in the "Good Practice Guidance" and "Guidelines".

Introduction of GHG Inventory

- In order to produce high quality inventories, despite the varying experience and resources of inventory compilers, the "2006 Guidelines" uses the "Tiers", "Key categories" and "Decision trees".

What are "Tiers"?

- Tiers
  - A tier represents a **level** of methodological **complexity**.
  - Tier1 is the basic method and default factors are supplied in IPCC Guidelines.
  - Tier2 requires country-specific information.
  - Tier3 is most demanding in terms of complexity and data requirements usually involving detailed modeling.

What are " Key Categories"?

- Key Categories
  - The concept of key category is used to identify the categories that have a significant influence on a country's total inventory of GHG.
  - Key categories should be the priority for countries during inventory resource allocation for data collection, compilation and quality assurance/ quality control.
  - "Key Categories" will be explained in detail in the later lecture.

What are "Decision trees"?

- Decision trees
  - Decision trees for each category help the inventory compiler navigate through the guidance and select the appropriate tiered methodology for their circumstances based on their assessment of **key categories** and data availability.
  - In general, it is good practice to use higher tier methods for **key categories**, unless the resources requirements to do so are prohibitive.

2. Outline of Energy Sector

- The energy sector mainly comprises of:
  - Exploration and exploitation of primary energy sources,
  - Conversion of primary energy sources into more useable energy forms in refineries and power plants
  - Transmission and distribution of fuels
  - Use of fuels in stationary and mobile applications (Stationary Combustion and Mobile Combustion)

Introduction of Energy Sector

- Energy Sector is usually the MOST important sector
  - Typically contributes; 90% of CO_2 emissions and 75% of total GHG emissions (in developed countries)
  - CO_2 accounts typically for 95% of energy sector emissions (other balance are CH_4 and N_2O)
  - Stationary combustion is usually responsible for about 70% of GHG emissions from the energy sector.
  - Mobile combustion (road and other traffic) causes about one quarter of the emissions in the energy sector.

Activity and Source Structure in the Energy Sector

- 1A Fuel Combustion Activity
  - 1A1 Energy Industries
  - 1A2 Manufacturing industries and Construction
  - 1A3 Transport
  - 1A4 Other Sectors
  - 1A5 Non-Specified
- 1B Fugitive emissions from Fuels
  - 1B1 Solid Fuels
  - 1B2 Oil and Natural Gas
  - 1B3 Other emissions from Energy Production
- 1C Carbon dioxide Transport and Storage
  - 1C1 Transport of CO_2
  - 1C2 Injections and Storage
  - 1C3 Other

Fuel types (2006 IPCC Guidelines)

- Liquid (Crude oil and petroleum products)
  - Crude Oil, Gasoline, Kerosene, Diesel Oil, Residual Fuel Oil, Naphtha, Refinery Feedstocks, …etc.
- Solid (Coal and Coal Products)
  - Anthracite, Coking Coal, Other Bituminous Coal, Lignite, Coke, Coke Oven Gas, Blast Furnace Gas, …etc.
- Gas (Natural Gas)
- Other Fossil Fuels (Waste, Peat)
- Biomass
  - Wood, Sulphite Lyes (Black Liquor), …etc.

Basic Information of Energy Sector

- The basic equation : Emissions = Activity Data x Emission Factor
- Emissions arise from "Energy Sector" by combustion and as fugitive emissions, or escape without combustion.
- In the Energy Sector the changes are minimal.

Transition of Energy Sector from the Revised 1996 IPCC Guidelines

- No "real" changes since the revised 1996 IPCC Guidelines
- What is new?
  - Clear separation of Sectoral Approach and Reference Approach
  - Clear treatment of non-energy use of fuel
  - New chapter on CO_2 Capture and Storage
  - Methods for abandoned coal mines
  - New methodologies and emission factors to reflect developing country circumstances as well
  - Improved decision trees facilitating more accurate emission estimation
  - Uncertainty information for all default values

"Sectoral Approach" vs "Reference Approach"

Sectoral Approach	Reference Approach
Sectoral Approach is based on fuel consumption by fuel type and user. Sectoral Approach should be used for estimating emissions. <All gases>	Reference Approach is based on national energy balances at a summary level. Reference Approach should be used as a QA/QC check. <CO_2 only>

Definition of Emissions from Fuel Combustion and from Industrial Process

Fuel Combustion	The internal oxidation of materials within an apparatus that is designed to provide heat or mechanical work to process, or for use away from the apparatus. If the derived fuels are transferred for combustion in another source category, the emissions should be reported in the Energy Sector.
Industrial Process	Combustion emissions from fuels obtained directly or indirectly from the feedstock for Industrial Processes are allocated to the Industrial Processes.

Some Questions

- Q1; If a blast furnace gas is combusted entirely with the Iron and Steel Plant, which sector are emissions reported in?
- A1; Industrial Processes and Product Use (IPPU) Sector. Because seeing this process in broad perspective, the fuels usage is closed on site.
- Q2; If part of this gas is delivered to a nearby brick work for heat production, which sector are emissions reported in?
- A2; Energy Sector. Because the "brick work" gets "Energy" from blast furnace gas and the "brick work" emits CO_2.

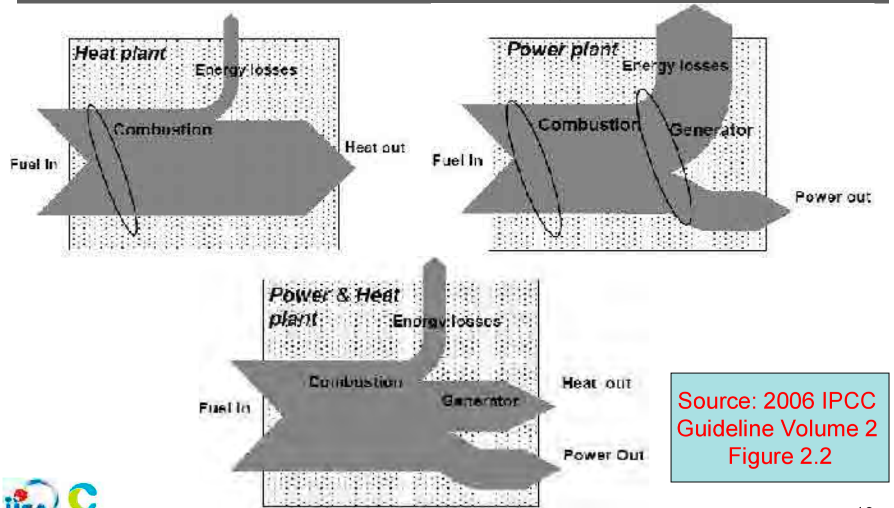
Some Questions

- Q3; If surplus methane or hydrogen from the steam cracking of naphtha is combusted within the petrochemical site for another process, which sector are emissions reported in?
- A3; IPPU Sector. Because fuels are only used on site.
- Q4; If the gases are passed to a nearby refinery for fuel use, which sector are emissions reported in?
- A4; Energy Sector. Because these gases are source of "Energy" in the refinery.

Outline of Stationary Combustion

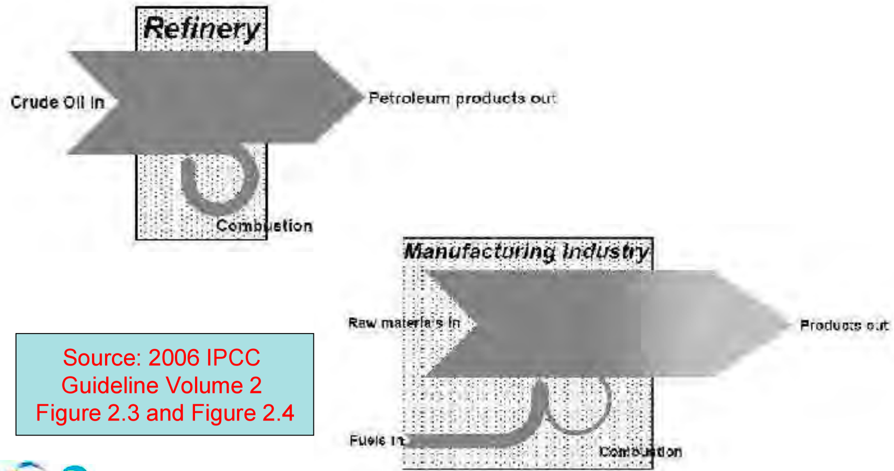
- What is "Stationary Combustion" ?
- Energy Industries (for example; Electrical Power Plants, Heat Plants, Petroleum Refining…)
- Manufacturing Industries and Construction (for example; Iron and Steel, Non-Ferrous Metals, Chemical, Pulp, Paper and Print, Food, …etc.)
- Other Sector (for example; Commercial, Residential, Agriculture, …etc.)
- Non-Specified (for example; military, …etc.)

Example of Energy Flows (Power and Heat Plants)



Source: 2006 IPCC Guideline Volume 2 Figure 2.2

Example of Energy Flows (Refinery and Manufacturing Industry)



Source: 2006 IPCC Guideline Volume 2 Figure 2.3 and Figure 2.4

3. The general method of calculating the GHG of Energy Sector

- Tier1 : Fuel Consumption
  (National Energy Statistics) x EF (Default)
- Tier2 : Fuel Consumption
  (National Energy Statistics) x EF (Country-specific)
  - Compare any country-specific EF with the default EF
- Tier3 : Fuel Consumption
  (fuel, technology) x EF (GHG, fuel, technology)
  - Technology ; any device, combustion process, fuel property, quality of maintenance…etc…

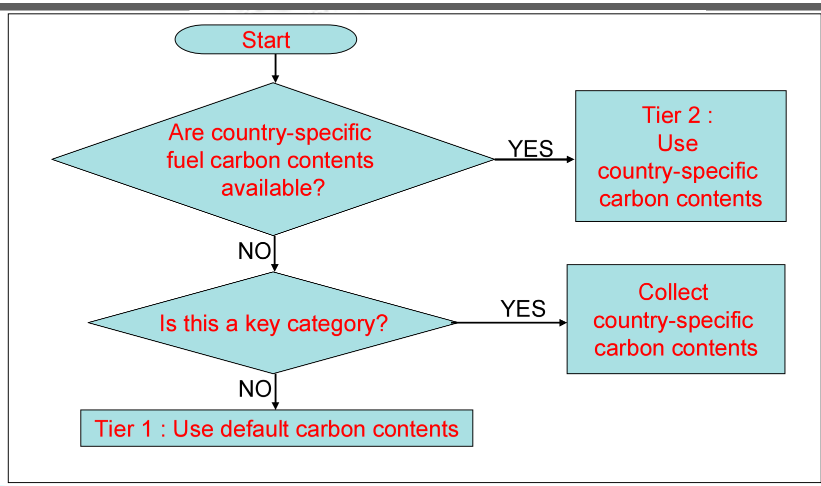
Activity Data and Emission Factor

- Main Activity Data : "Energy Statistics"
- Sub Activity Data : "Other Statistics"
- Main Emission Factor Source : IPCC Guidelines for National Greenhouse Gas Inventory or the IPCC Emission Factor Database
- Sub Emission Factor Source : Country-specific EFs (very important)

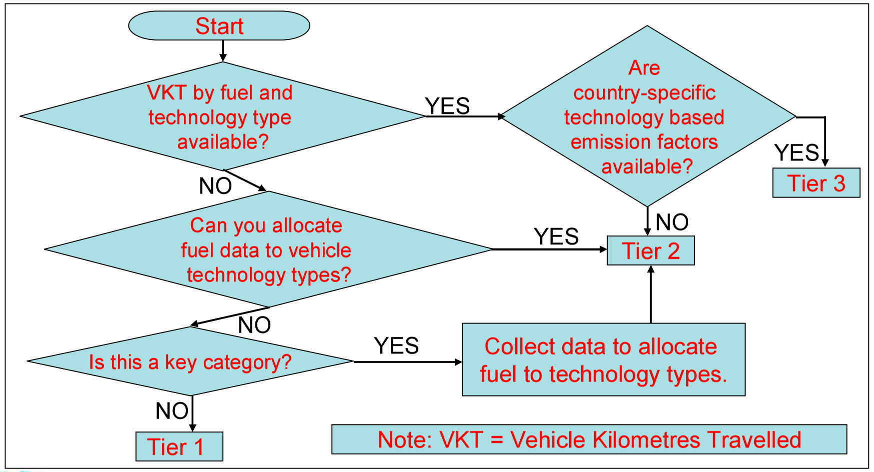
Introduction of Mobile Combustion

- Sources : road, off-road, air, railways, and water-borne navigation
- Emissions : CO2, CH4, N2O
- Characteristics is very important (such as vehicle types, ageing on catalytic control, age of fleet, maintenance, fuel sulphur content, patterns of use,…etc.)

Example of Decision Tree for CO2 Emissions from fuel combustion in road vehicles



Example of Decision Tree for CH4 & N2O Emissions from fuel combustion in road vehicle



Tier1, Tie2 and Tier3 (Road Transportation)

- Tier1: CH4 and N2O, CO2(Tier1 and Tier2)
- $\text{Emission} = \sum_a [\text{Fuel}_a \cdot \text{EF}_a]$ a: fuel type
- Tier2: CH4 and N2O
- $\text{Emission} = \sum_{a,b,c} [\text{Fuel}_{a,b,c} \cdot \text{EF}_{a,b,c}]$
- b: vehicle type, c: emission control technology
- Tier3: CH4 and N2O
- $\text{Emission} = \sum_{a,b,c,d} [\text{Distance}_{a,b,c,d} \cdot \text{EF}_{a,b,c,d}] + \sum_{a,b,c,d} C_{a,b,c,d}$
- d: operating conditions, Distance = distance travelled,
- C = emissions during warm-up phase

Railway and Water-Borne Navigation

- Tier1 : $\text{Emission} = \sum_j [\text{Fuel}_j \cdot \text{EF}_j]$ j = fuel type
- : $\text{Emission} = \sum_{a,b} [\text{Fuel}_{a,b} \cdot \text{EF}_{a,b}]$
- a = fuel type, b = water-borne navigation type
- Tier2 : $\text{Emission} = \sum_i [\text{Fuel}_i \cdot \text{EF}_i]$ i = locomotive type
- : $\text{Emission} = \sum_{a,b} [\text{Fuel}_{a,b} \cdot \text{EF}_{a,b}]$
- country-specific emission factors
- Tier3 : skip

Question (About Fuel Combustion)

- Q: Generally, CO2 emissions from fuel combustion are the most important category in the GHG inventory. Therefore we should calculate in Tier3 (Detailed Method). (Is it true?)
- A: Using a Tier 3 approach to estimate emissions of CO2 is often unnecessary because emissions of CO2 do not depend on the combustion technology. However, plant-specific data on CO2 emissions are increasingly available and they are of increasing interest because of the possibilities for emission trading.

Fugitive Emissions (Coal Mines)

- Underground Coal Mines ; Tier1 and Tier2 (basic equation)
  - Greenhouse gas emissions = "Raw Coal Production" x "Emission Factor" x "Units Conversion Factor"
- Surface Coal Mining ; Tier1 and Tier2 (basic equation)
  - CH_4 = Surface mining + Post-mining
  - CH_4 emissions = "CH_4 Emission Factor" x "Surface Coal Production" x "Conversion Factor"
- Abandoned Underground Coal Mines ; Tier1 and Tier2 (basic equation)
  - Greenhouse gas emissions = "Number of Abandoned Coal Mines remaining unflooded" x "Fraction of Gassy Coal Mines" x "Emission Factor x "Units Conversion Factor"

Fugitive Emissions (Oil and NG)

- Emission Sources : Venting, Flaring, Equipment leak, Storage losses, Exploration, Production and Upgrading, Transport, Refining, Distribution, …etc.
- Tier1: Emissions = "Activity Value" x "Emission Factor"
  - EF : Tier 1 default emission factors are presented in 2006 IPCC Guideline.
  - Activity Data : typical national oil and gas statistics (limited information)

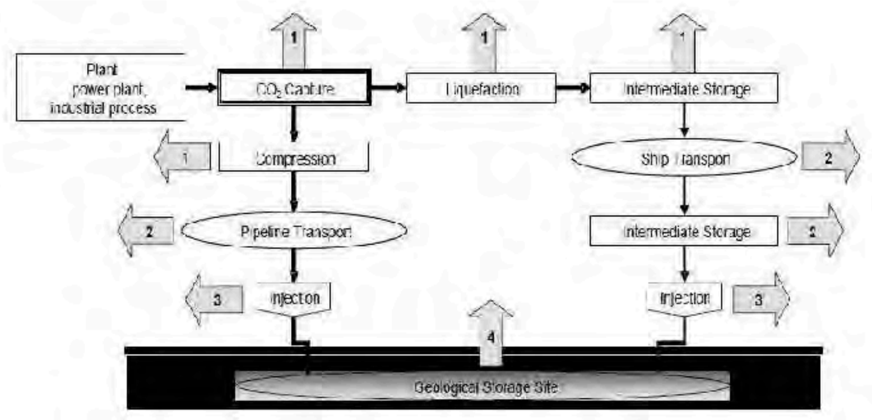
Question (About Fugitive Emissions)

- Q: If the surplus CH_4 of the natural gas field are combusted in on-site power plant, should these emissions be calculated in the "Fugitive Emissions" category?
- A: No. These Emissions should be calculated in the "Fuel Combustion" category, because emissions from fuel combustion for production of useful heat or energy by stationary sources are reported in "Fuel Combustion" category.
- The emissions from the flaring and the venting should be in the "Fugitive Emissions" category.

Carbon Dioxide Transport, Injection and Geological Storage

- Carbon Dioxide Capture and Storage (CCS)
  - CO_2 Capture ("1"): The system boundary for capture includes compression and any dehydration or other conditioning of the CO_2 that takes place before transport.
  - Emissions from Transport of Captured CO_2 ("2"): Pipelines, ships and so on.
  - Emissions from Injection of Captured CO_2 ("3"): At the injection site. (storage facilities, any distribution manifold, distribution pipelines to wells, injection well, etc.)
  - Geological Storage of Captured CO_2 ("4"): Deep saline formations, Depleted or partially depleted oil fields, Depleted or partially depleted Natural Gas field, Coal seam

Schematic Representation of the Carbon Capture and Storage Process



Source: 2006 IPCC Guideline Volume 2 Figure 5.1

Question (About Carbon Dioxide Capture and Storage)

- Q: Are there some projects of CCS in Thailand? (I do not know. So, I want to know!)
- A: There are some projects…or no projects.
- A: There are some projects in Japan.
  - Sumitomo Chemicals Plant, Chiba, Japan/Kokusai Carbon Dioxide
  - RITE R&D Projects for Geological Sequestration of Carbon Dioxide
  - IGCC Demonstration Plant, Nakoso Power Station, etc.

4. The method of calculating the GHG of Energy Sector in Japan

- Emissions = "Activity Data" x "Emission Factor" x "Global Warming Potential"
- Activity Data: (Mainly) "Japan's General Energy Statistics"
- Emission Factor: Country-specific emission factors
- 1,160,455 Gg-CO2 (90.5% of Japan's total GHG emissions)
- Data source is "National Greenhouse Gas Inventory Report of JAPAN (Ministry of the Environment, Japan, Greenhouse Gas Inventory Office of Japan (GIO), CGER, NIES)"

Characteristics of Japan's General Energy Statistics

- Matrix ("Columns" (energy sources) x "Rows" (sectors))
  - 11 major energy source categories, Sub-categories and a more detailed breakdown of the sub-categories (about 160 categories)
  - 3 major sectors, Sub-categories and a more detailed breakdown of the sub-categories (about 200 categories)

For Example : Japan's Energy Statistics

Japanese Emission Factor of "Fuel Combustion Category"

- CO2 emission factors: Default value and Country-specific value
  - 2006 IPCC Guideline default value
  - Adopted value of other fuel
  - Country-specific value
- CH4 and N2O emission factors: Tier 2 country-specific emission factors
  - based on data obtained from surveys conducted in Japan

Setting method of the emission factor

- Setting from scientific theory value (CO2 from energy Combustion, …etc.)
- Measurement made at the factories (Mainly CH4 and N2O)
- The results of surveys in Japan (Mainly Agricultural Sector and Waste Sector)
- The default value of the IPCC guideline (N2O from civil aviation, …etc.)

The method of calculating the GHG Emissions of other categories in Japan

- Fugitive Emissions
  - This category is not important in Japan.
    - 446 Gg-CO2/year (0.03 % of Japan's total GHG emissions)
    - The emissions have decreased by 85% compared to 1990.
- Carbon dioxide Transport and Storage
  - This category is not estimated yet.

5. Issues of Energy Sector in Thailand

- Which categories is the key categories? Which categories is important? (Sub-category is not clear.)
- Is there overestimated sub-category?
- Is there underestimated sub-category?
- Is there double counting sub-category?
- Is there omitted sub-category?

The energy statistics candidate in Thailand

- First : Thailand Energy Situation (http://www.dede.go.th/ded
- Second : Energy Statistics of Non-OECD Countries (International Energy Agency)
- Third : Energy Balances and Electricity Profiles (United Nations)
- Fourth :U.S. Energy Inform (EIA; http://www.eia.doe.gov/)
- Fifth : Enerdata (http://www.enerdata.net/)

Top priority energy statistics

Use in cross-checking or QA/QC process

6. Practice

- The simple energy balance table is distributed.
- And, the emission factors of IPCC default value is distributed, too.
- Please make an inventory in energy sector from these.
- Please calculate in Tier1 (simple) method.
- Let's proceed with this work while you discuss it in your group.
- Please discuss which category is suitable for allocating CO2 emissions from the electric powers.

- ありがとうございました
- ขอบคุณ มาก ครับ/ค่ะ
- Thank you very much

Appendix

- "Japanese Energy Statistics" and "Common Reporting Format (CRF)"
- Emission factors (CH4 and N2O)
- Others

Correspondence between sectors of General Energy Statistics and of the CRF

CRF			General Energy Statistics
1A1		Energy Industries	
	1A1a	Public Electricity and Heat Production	#2110 Power Generation, General Electric Utilities
			#2911 Own use, General Electric Utilities
			#2150 Power Generation, Independent Power Producing
			#2912 Own use, Independent Power Producing
			#2550 District Heat Supply
			#2913 Own use, District Heat Supply
	1A1b	Petroleum Refining	#2916 Own use, Oil Refinery
	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)

Correspondence between sectors of General Energy Statistics and of the CRF

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

Correspondence between sectors of General Energy Statistics and of the CRF

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, Agriculture, Forestry & Fishery
			#9610 Non-Energy, Non-Manufacturing Industry
1A5		Other	
	1A5a	Stationary	- -
	1A5b	Mobile	- -

Fuel type of Japan's General Energy Statistics and Trends in gross calorific value of each fuel type (part1)

	Fuel	Unit	1990	1995	2000	2005	2006	2007	2008
Coal	Steel Making Coal	MJ/kg	31.81	31.81	28.90	29.00	29.00	29.00	29.00
	Coking Coal	MJ/kg	31.81	30.53	28.13	29.10	29.10	29.10	29.10
	PCI Coal	MJ/kg	31.81	30.74	28.23	28.20	28.20	28.20	28.20
	Imported Steam Coal	MJ/kg	25.95	25.95	26.33	25.70	25.70	25.70	25.70
	Imported Coal (for general use)	MJ/kg	25.95	25.95	26.30	25.70	25.70	25.70	25.70
	Imported Coal (for power generation)	MJ/kg	21.92	26.13	26.39	25.49	25.65	25.52	25.27
	Indigenous Steam Coal	MJ/kg	24.28	21.28	22.50	22.50	22.50	22.50	22.50
	Underground	MJ/kg	24.28	24.28	23.90	23.90	23.90	23.90	23.90
	Open Pit	MJ/kg	18.70	18.70	18.70	18.70	18.70	18.70	18.70
	Hard Coal, Anthracite & Lignite	MJ/kg	27.21	27.21	27.20	26.90	26.90	26.90	26.90
Coal Products	Coke	MJ/kg	30.14	30.14	30.10	29.40	29.40	29.40	29.40
	Coal Tar	MJ/kg	37.26	37.26	37.26	37.26	37.26	37.26	37.26
	Coal Briquette	MJ/kg	23.90	23.90	23.90	23.90	23.90	23.90	23.90
	Coke Oven Gas	MJ/m3N	21.51	21.57	21.27	21.42	21.38	21.28	21.20
	Blast Furnace Gas	MJ/m3N	3.51	3.59	3.64	3.41	3.41	3.41	3.41
	Converter Furnace Gas	MJ/m3N	8.37	8.37	8.41	8.41	8.41	8.41	8.41
Oil	Crude Oil for Refinery	MJ/l	38.34	38.27	38.22	38.11	[illegible]	38.16	38.15
	Crude Oil for Power Generation	MJ/l	39.05	39.15	39.59	39.50	39.26	39.55	39.54
	Bituminous Mixture Fuel	MJ/kg	30.00	30.81	29.80	22.44	22.44	22.44	22.44
	Natural Gas Liquid & Condensate	MJ/l	35.74	35.51	35.41	35.33	35.04	35.46	35.30

Fuel type of Japan's General Energy Statistics and Trends in gross calorific value of each fuel type (part2)

Oil Products	Stack Gasoline	MJ/l	35.33	33.69	33.57	33.50	33.55	33.54	33.58
	Stack Kerosene	MJ/l	36.75	36.70	36.76	36.74	36.71	36.74	36.73
	Stack Diesel Oil or Gas Oil	MJ/l	38.50	38.09	38.08	38.07	38.08	38.07	38.06
	Stack Fuel Oil	MJ/l	41.32	41.77	41.79	41.77	41.79	41.81	41.83
	Cracked Gasoline	MJ/l	33.93	33.63	33.57	33.56	33.55	33.54	33.56
	Cracked Diesel Oil or Gas Oil	MJ/l	38.50	38.50	38.58	38.57	38.55	38.57	38.56
	Feedstock Oil for Refinery and Mixing	MJ/l	38.34	38.27	38.22	38.11	38.11	38.16	38.15
	Naphtha	MJ/l	33.63	33.63	33.57	33.55	33.55	33.54	33.58
	Reformed Material Oil	MJ/l	35.06	35.09	35.09	35.09	35.09	35.05	35.09
	Gasoline	MJ/l	34.57	34.61	34.60	34.59	34.59	34.56	34.57
	Premium Gasoline	MJ/l	35.09	35.08	35.08	35.09	35.08	35.05	35.09
	Regular Gasoline	MJ/l	34.46	34.46	34.46	34.49	34.48	34.46	34.48
	Jet Fuel	MJ/l	36.42	36.42	36.70	36.70	36.70	36.70	36.70
	Kerosene	MJ/l	36.75	36.72	36.70	36.74	36.74	36.74	36.73
	Gas Oil or Diesel Oil	MJ/l	38.11	38.08	38.18	37.70	37.86	37.90	37.91
	Fuel Oil A	MJ/l	39.71	39.61	39.12	39.05	39.27	39.05	39.23
	Fuel Oil B/C	MJ/l	42.68	42.18	41.57	42.00	41.90	42.10	42.17
	Fuel Oil B	MJ/l	40.19	40.19	40.40	40.40	40.40	40.40	40.40
	Fuel Oil C	MJ/l	42.69	42.18	41.57	42.00	41.96	42.16	42.17
	Fuel Oil C for Power Generation	MJ/l	41.09	41.12	41.25	41.10	41.34	41.31	41.31
	Lubricating Oil	MJ/l	40.18	40.18	40.20	40.20	40.20	40.20	40.20
	Asphalt	MJ/kg	41.19	41.15	40.95	40.87	40.84	41.15	41.15
	Non-Asphalt Heavy Oil Products	MJ/kg	41.64	41.15	40.95	40.97	40.94	41.13	41.15
	Oil Coke	MJ/kg	35.58	35.58	35.60	29.90	29.90	29.90	29.90
	Oil Furnace Gas	MJ/m3N	8.37	8.37	8.41	8.41	8.41	8.41	8.41
	Refinery Gas	MJ/m3N	39.35	39.35	44.90	44.90	44.90	44.90	44.90
	Liquefied Petroleum Gas	MJ/kg	50.23	50.23	50.20	50.80	50.80	50.80	50.80
Natural Gas	Liquefied Natural Gas	MJ/kg	54.60	54.57	54.55	54.57	54.53	54.58	54.58
	Indigenous Natural Gas	MJ/m3N	42.06	42.09	43.55	42.57	45.87	44.91	44.71
	Indigenous Natural Gas	MJ/m3N	42.45	42.62	45.40	42.57	46.0	44.91	44.7
	Coal Mining Gas	MJ/m3N	35.00	36.00	15.70	15.70	16.70	16.70	16.70
	Obtained from Crude Oil	MJ/m3N	45.15	42.39	42.88	42.87	45.87	44.81	44.71
Town Gas	Town Gas	MJ/m3N	41.86	41.86	41.10	44.80	44.80	44.80	44.80
	Town Gas	MJ/m3N	41.86	41.86	41.10	44.80	44.80	44.80	44.80
	Small Scale Town Gas	MJ/m3N	100.50	100.50	100.57	100.50	100.50	100.50	100.50

CH4 Emission Factors for different fuels and furnaces

Furnace type	Fuel type	Emission factor	Remarks
Boiler	Fuel oils B and C, crude oil	0.10	Average of 9 facilities
Boiler	Fuel oil A, diesel oil, kerosene, naphtha, other liquid fuels	0.26	Average of 2 facilities
Boiler	Gaseous fuel	0.23	Average of 5 facilities
Boiler	Steam coal, coke, other solid fuels	0.13	Average of 7 facilities
Boiler	Harvested wood, charcoal	75	Average of 4 facilities
Boiler	Pulping waste liquor	4.2	Average of 2 facilities
Sintering furnace for smelting of metals (except copper, lead, zinc)	Solid fuel, liquid fuel, gaseous fuel	31	Average of 6 facilities
Pelletizing furnace (steel and non-ferrous metal)	Solid fuel, liquid fuel, gaseous fuel	1.7	Average of 2 facilities
Metal rolling furnace, metal treating furnace, metal forging furnace	Liquid fuel, gaseous fuel	5.47	Average of 11 facilities
Petroleum and gas furnaces	Liquid fuel, gaseous fuel	0.16	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	29	Average of 6 facilities
Other drying kilns	Solid fuel, liquid fuel, gaseous fuel	6.6	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	0.83	Average of 14 facilities
Other industrial furnaces	Gaseous fuel	2.3	Average of 6 facilities
Gas turbine	Liquid fuel, gaseous fuel	0.81	Average of 11 facilities
Diesel engine	Liquid fuel, gaseous fuel	0.79	Average of 3 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

N2O Emission Factors for different fuels and furnaces

Furnace type	Fuel type	Emission factor	Remarks
Boiler	Fuel oils B and C, crude oil	0.22	Average of 10 facilities
Boiler	Fuel oil A, diesel oil, kerosene, naphtha, other liquid fuels	0.19	Average of 2 facilities
Boiler	Gaseous fuel	0.17	Average of 5 facilities
Boiler (other than fluidized bed boilers)	Solid fuel	0.85	Average of 9 facilities
Normal pressure fluidized bed boiler	Solid fuel	54	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	0.017	Average of 2 facilities
Petroleum furnace, gas furnace	Liquid fuel, gaseous fuel	0.21	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, oilgas, other gaseous fuels	0.14	Average of 3 facilities
Other industrial furnace	Solid fuel	1.1	Average of 20 facilities
Other industrial furnace	Liquid fuel	1.8	Average of 31 facilities
Other industrial furnace	Gaseous fuel	1.2	Average of 18 facilities
Gas turbine	Liquid fuel, gaseous fuel	0.58	Average of 12 facilities
Diesel engine	Liquid fuel, gaseous fuel	2.2	Average of 9 facilities
Gas engine, petrol engine	Liquid fuel, gaseous fuel	0.85	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

Notes of Stationary Combustion

- Useful source of information
  - "Energy Statistics Manual" (IEA, downloaded free)
  - National data of IEA energy statistics (country's data free of charge)
- Avoiding Double Counting Activity Data
  - IPPU : Synthesis gas, By-product fuels (coke oven gas and blast furnace gas, etc.)…
  - AFOLU : Wood chips, charcoal
  - WASTE : Waste Incineration (energy is recovered from waste combustion.)

Others

- Uncertainty information is written clearly such as the default value, lower limit value and upper limit value as 95% confidence interval (uncertainty).
- New chapter of CO2 Capture and Storage is set up.
  - This category is positioned as outside category of "Stationary Combustion" and "Industrial Processes & Product Use". CO2 Capture and Storage include CO2 Transport.
- Closed, or abandoned, underground coal mines may continue to be a source of greenhouse gas emissions for some time.
- Tier 1 and Tier 2 methods, based on a database of abandoned mines are provided and default emission factors are given.

The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Overview of Industrial Processes and Product Use (IPPU) Sector

14 September, 2010

GHG Inventory

Fumihiko KUWAHARA

Contents of "IPPU Sector" Training Program

1. Outline of Industrial Processes and Product Use (IPPU) Sector
2. The general method of calculating the GHG of IPPU Sector
3. The method of calculating the GHG of IPPU Sector in Japan
4. Issues of IPPU Sector in Thailand
5. Practice

1. Outline of IPPU Sector

- Dynamic sector with rapid technological change
- GHG emissions are produced from a wide variety of industrial activities.
- It is important to understand what kind of process is target.
- It is important to visualize and understand the industrial processes.
- Greatly improved user-friendliness – many simplifications including new Tier 1 methods → Tier 1 methods are shown as follows;

2. The general method of calculating the GHG of IPPU Sector

- Chapter 1: Introduction
- Chapter 2: Mineral Industry
- Chapter 3: Chemical Industry
- Chapter 4: Metal Industry
- Chapter 5: Non-Energy Products from Fuels and Solvent Use
- Chapter 6: Electronics Industry
- Chapter 7: Emissions for Fluorinated Substitutes for Ozone Depleting Substances
- Chapter 8: Other Product Manufacture and Use

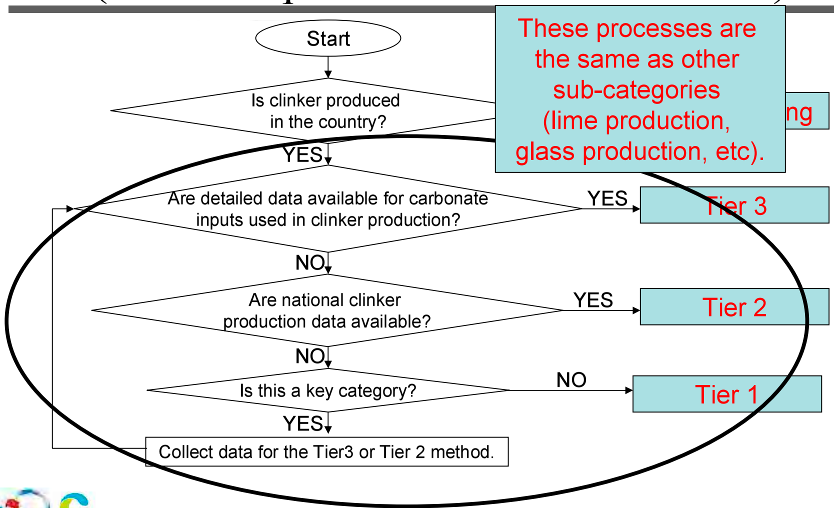
Chapter 2: Mineral Industry

- Consistent approaches are based on carbonate content of inputs for all sources.
- Main source categories are Cement Production, Lime Production and Glass Production.
- The use of carbonate raw materials in the production and use of a variety of mineral industry products.

Basic Approach (Basic Method of Thinking)

- Equation example
  - $CaCO_3$ + heat → CaO + **CO_2**
  - $CaCO_3 + H_2SO_4$ → $CaSO_4 + H_2O$ + **CO_2**
- Tier1 methods (Basic Equation)
  - Cement Production : CO_2 Emissions = [("Cement Production" x "Clinker Fraction of Cement") – "Import of Clinker" + "Export of Clinker"] x "Emission Factor"
  - Lime Production : CO_2 Emissions = "Lime Production" x "Emission Factor"
  - Glass Production : CO_2 Emissions = "Glass Produced" x "Emission Factor" x (1 – "Cullet Ratio for Process")

Basic Decision Tree of "Mineral Industry" (For example : "Cement Production")



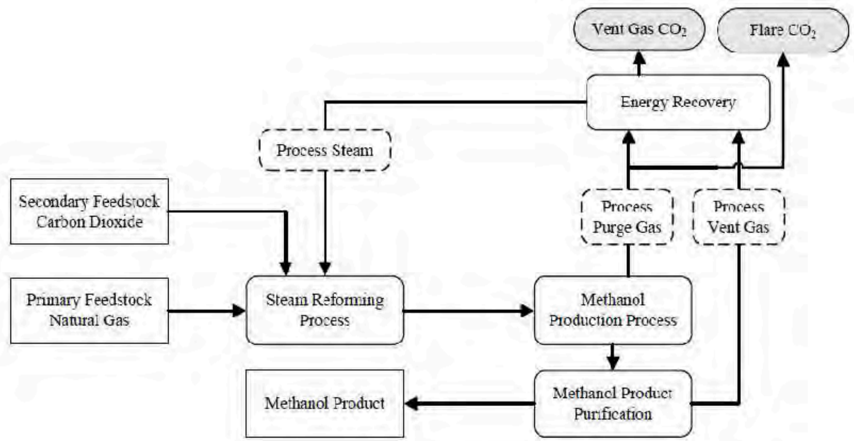
Question (Mineral Industry)

- Q: What are the Main Sources of GHG Emissions?
- A: The INPUTS (Raw Materials) are the main sources of GHG emissions.
- A: The process-released CO_2 emissions are the results from the use of carbonate raw materials in the production and use of a variety of mineral industry production.

Chapter 3: Chemical Industry

- Ammonia Production
- Nitric Acid Production
- Adipic Acid Production
- Production of Caprolactam, Glyoxal, and Glyoxylic Acid (New Sources)
- Production of Carbide
- Production of Titanium Dioxide (New Sources)
- Production of Soda Ash
- CO2 from various Petrochemical Processes (New Sources)
- Fluorochemical Production (fugitive and by-product emissions)

Example: Methanol Production feedstock-product flow diagram



Reference: Figure 3.11 of "2006 IPCC Guidelines"

Please check these figures

- 2006 IPCC Guidelines present some figures of "Chemical Industry Emissions".
- Figure 3.12 "Ethylene dichloride production feedstock-product flow diagram"
- Figure 3.13 "Ethylene oxide production feedstock-product flow diagram"
- Figure 3.14 "Acrylonitrile production feedstock-product flow diagram"
- Figure 3.15 "Carbon black production feedstock-product flow diagram"

Example : Tier 1 methods (Chemical Industry)

- Ammonia : CO2 Emissions
  = "Ammonia Production"
  x "Fuel Requirement per unit of output"
  x "Carbon content Factor of the Fuel"
  x "Carbon Oxidation Factor of the Fuel"
  x "44/12"
  – "CO2 Recovered"
  - * Fuel is a raw material of ammonia : Mainly Natural Gas (CH4) or Hydrocarbon (Coal or oil)…
- Nitric Acid : N2O Emissions
  = "Nitric Acid Production"
  x "Emission Factor"
- Carbide : CO2 Emissions
  = "Petroleum Coke Consumption or Carbide Production"
  x "Emission Factor"
- And so on…

Questions (Chemical Industry)

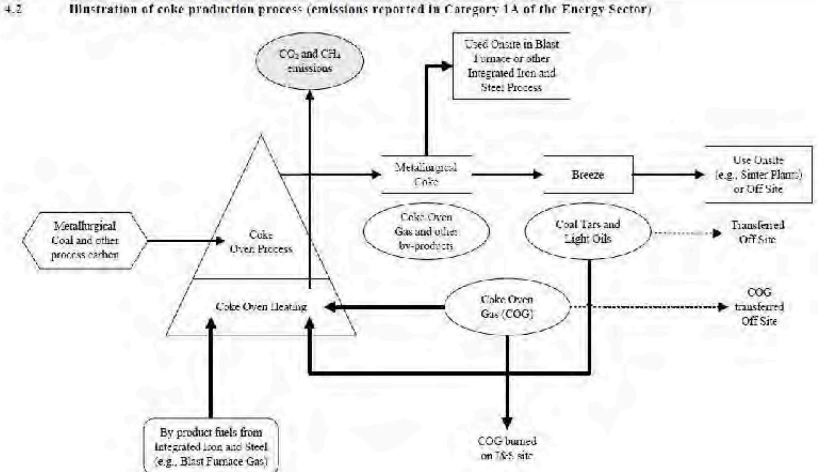
- Q1 What is the INPUT (raw material)?
- A1 Ammonia : Hydrocarbon (CH4, or other fossil fuels)
- A1 Nitric Acid : Ammonia
- A1 Carbide : Silica sand or quartz and petroleum coke
- Q2 What is the OUTPUT (production)?
- A2 Ammonia, Nitric Acid, Silicon Carbide, Calcium Carbide, Titanium dioxide, etc.
- Q3 What is the GHG?
- A3 CO2, CH4, N2O, HFCs, …

Chapter 4: Metal Industry

- Iron and Steel, and Metallurgical Coke Production
- Ferroalloy Production
- Aluminium Production
- Magnesium Production
- Lead Production (New Sources)
- Zinc Production (New Sources)

For example: Illustration of coke production process

Figure 4.2 Illustration of coke production process (emissions reported in Category 1A of the Energy Sector)



Reference: Figure 4.2 of "2006 IPCC Guidelines"

Please check these figures.

- 2006 IPCC Guidelines present some figures of "Iron & Steel and Metallurgical Coke Production".
- Figure 4.3 "Illustration of sinter production process"
- Figure 4.4 "Illustration of pig iron production processes"
- Figure 4.5 "Illustration of steel production processes"

For example : Tier 1 methods (Metal Industry)

- Coke Production (Iron, etc.) : CO2 or CH4 Emissions = "Quantity of Coke produced nationally" x "EF_{CO2} or EF_{CH4} "
- Ferroalloy : CO2 Emissions = "Production of ferroalloy" x "Emission Factor"
- Aluminum : CO2 Emissions = "Metal Production from Prebake Process" x "EF_P" + "Production from Soderberg Process" x "EF_S"
- Magnesium : CO2 Emissions = "Magnesium Production from dolomite" x "EF_d" + "Magnesium Production from magnesite" x "EF_{mg}"

More detailed information (Metal Industry)

- Coke is primarily used in the blast furnace to make iron. Coke is also used in other metallurgical process, such as the manufacture of cast iron, ferroalloys, lead, and zinc, and in kiln to make lime and magnesium.
- Many iron and steel facilities are integrated with on-site coke production.
- There is a risk of double counting or omission in either the "Industrial Processes" or the "Energy Sector", because the coke production is "Energy", iron and steel production is "IPPU".

Questions (Metal Industry)

- Q1: Which sector are the emissions reported in, if the CO2 are emitted from iron and steel production?
- A1: These emissions should be reported in the IPPU Sector, because the primary use of carbon sources is to produce pig iron.

Questions (Metal Industry)

- Q2: Which sector are the emissions reported in, if CO2 are emitted from coke production?
- A2: Though metallurgical coke is produced either at the iron and steel facility or at separated facilities, these emissions should be reported in the Energy Sector, because the coke production is labeled as "Energy" Sector.

More detailed information (Metal Industry)

- Creating potential double counting issues, because there may be flows of by-products (e.g. coke oven gas, blast furnace gas, coke oven by-products) between the coke production facility and the iron and steel production facility.

Questions (Metal Industry)

- Q3: Which sector are the emissions reported in, if CO2 are emitted from coke oven gas at an iron and steelmaking facility?
- A3: These emissions should be reported in the IPPU Sector, because the carbon is consumed in the form of coke oven gas at an **iron and steelmaking facility**. It depends on where they are consumed.

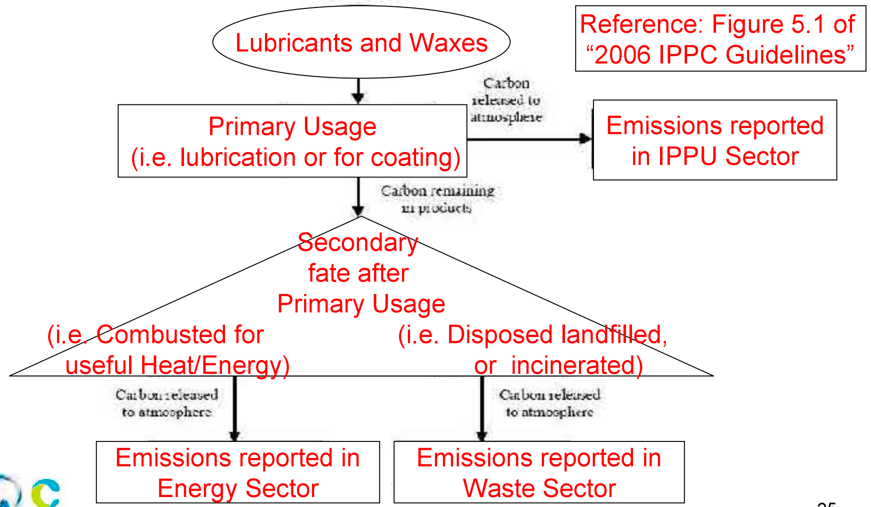
Questions (Metal Industry)

- Q4: Which sector are the emissions reported in, if CO2 are emitted from blast furnace gas at an onsite coke production facility?
- A4: These emissions should be reported in the Energy Sector, because the carbon is consumed in the form of blast furnace gas at an onsite **coke production facility**. It depends on where they are consumed.

Chapter 5: Non-Energy Products from Fuels and Solvent Use

- The First Use of Fossil Fuels as a Product for Primary Purposes other than
- i) combustion for energy purposes and
- ii) use as feedstock or reducing agent. (lubricants, paraffin waxes, bitumen/asphalt, and solvents)

For example : Illustration of "Sectoral allocation of emissions from Lubricants and Waxes"



For example : Tier 1 methods (Non-Energy Products from Fuels and Solvent Use)

- Lubricant Use : CO2 Emissions = "Lubricant consumption" x "Carbon content" x "Oxidised During Use (ODU) factor" x 44/12
- Paraffin Was Use : CO2 Emissions = "Wax consumption" x "Carbon content" x "ODU factor" x 44/12

Questions (Non-Energy Products from Fuels and Solvent Use)

- Q1 If the waste Lubricants or Waxes are combusted for useful Heat/Energy, which sector are emissions reported in?
- A1 Energy Sector.
- Q2 If the waste Lubricants or Waxes are disposed, landfilled or incinerated, which sector are emissions reported in?
- A2 Waste Sector.
- Q3 If the Lubricants or Waxes are used primarily, which sector are emissions reported in?
- A3 IPPU Sector.

Chapter 6: Electronics Industry

- Semiconductor, thin-film transistor flat panel display (TFT-TPD), and photovoltaic (PV) manufacturing
- The gases include CF_4, C_2F_6, C_3F_8, c-C_4F_8, c-C_4F_8O, C_4F_6, C_5F_8, CHF_3, CH_2F_2, NF_3 and SF_6.
- Process i) Plasma etching silicon containing materials
- Process ii) Cleaning chemical vapour deposition (CVD) tool chamber-walls where silicon has deposited

For example : Tier 1 methods (Electronics Industry)

- Etching and CVD Cleaning
  - GHG Emissions = "GHG Mass per Unit Area (m^2) of Substrate in each Electronics Industry Category" (EF) x "Quantity of substrate consumed during electronics manufacture" (Activity Data)
- Heat Transfer Fluids
  - GHG Emissions = "GHG Emissions per Gm^2 silicon consumed" (EF) x "Silicon consumed of Semiconductor Manufacturing Facilities" (Activity Data)

Chapter 7: Emissions for Fluorinated Substitutes for Ozone Depleting Substances

- Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs)
  - Refrigeration and air conditioning
  - Fire suppression and explosion protection
  - Aerosols
  - Solvent cleaning
  - Foam blowing
  - Other applications
- Actual Emissions ("Potential emission method" is now presented only as a reference scenario in the QA/QC section.)

What is the "Potential Emissions"?

- In the "Revised 1996 IPCC Guideline", Potential Emission methods are regarded as the basic methodology (Tier 1) for HFCs and PFCs emission estimates.
- Potential Emissions = "Production" + "Imports"– "Exports" – "Destruction"
- This method does not take into account accumulation or possible delayed release of chemicals over the short term (e.g., 10-15 years).

For example : Tier1 (Emissions for Fluorinated Substitutes for Ozone Depleting Substances)

- Emission-factor approach : Annual Emissions = "Net Consumption" x "Composite EF" (Net Consumption = Production + Import – Exports – Destruction)
- Mass-balance approach : Emissions = "Annual Sales of New Chemical" – ("Total Charge of New Equipment" – "Original Total Charge of Retiring Equipment")

Chapter 8: Other Product Manufacture and Use

- Section 8.2: SF6 and PFC emissions from electrical equipment
- Section 8.3: emissions from the manufacture and use of a wide variety of other industrial, commercial, and consumer products that contain SF6 and PFCs
- Section 8.4: Methods for estimating N2O emissions from anaesthetics, propellants, and other product uses

For example : Tier1 (Other Product Manufacture and Use)

- SF6 and PFCs from Electrical Equipment : Emissions = "EF" x "Activity"
- SF6 and PFCs from Other Use : SF6 Emissions = 740 (kg) x "Number of Planes"
- N2O from Product Uses : N2O Emissions = (0.5 x "Total Quantity of N2O supplied year t" + 0.5 x "Total Quantity of N2O supplied year t-1") x "EF"

Conclusions: general method of calculating the GHG of IPPU sector

- Industry has participated strongly in the IPCC Sector. Industry has good access to sector knowledge.
- Policies and voluntary actions already show an impact on emissions from several sources.
- Since 1996, there has been rapid expansion of knowledge about sources and gases, including emission trading schemes and voluntary reporting.
- The inventory compilers can have immediate benefit and wealth from a lot of information.

3. The method of calculating the GHG of IPPU Sector in Japan

- The emissions from Mineral Products are relatively large.
- Under the voluntary action plan, the emissions of some sub-categories have been reduced.
- An IPPU sector is the wide sector where all GHGs are related to.
- Data source is "National Greenhouse Gas Inventory Report of JAPAN (Ministry of the Environment, Japan, Greenhouse Gas Inventory Office of Japan (GIO), CGER, NIES)"

Emissions of IPPU in Japan (FY 2008 ; Gg CO_2-eq)

	CO2	CH4	N2O	HFCs	PFCs	SF6
Mineral	47,076.0					
Chemical	2,744.0	106.5	1,262.1			
Metal	155.8	15.0			14.7	652.5
Solvent and other Product Use			160.4			
Production of F-gas				701.4	523.8	1,288.2
Consumption of F-gas				14,564.0	4,077.6	1,820.6

The characteristic of the Japan's GHG Inventory (Industrial Process Sector : Part1)

- Mineral products
  - In 2008, emissions from this category occupied 3.7% of total GHG emissions (excluding LULUCF). (very important category !)
    - Japan's emission factors of Cement Production
    - EFcp = (CaO content in clinker exclude waste origin CaO) * 0.785
    - (Average CaO content in clinker –
    - Waste Origin CaO content in clinker) * 0.785

The characteristic of the Japan's GHG Inventory (Industrial Process Sector : Part2)

- Chemical products
  - In 2008, emissions from this category occupied 0.3% of total GHG emissions (excluding LULUCF).
    - N2O decomposition units were installed in adipic acid production plants in March 1999, and emissions since then have decreased dramatically.
- Metal production
  - CO2 generated by the oxidation of the coke used as a reduction agent is calculated in fuel Combustion Category (1.A.).

The characteristic of the Japan's GHG Inventory (Industrial Process Sector : Part3)

- Industrial Processes (HFCs, PFCs, SF6) Sectors have a larger uncertainty than other sector relatively.
- Production of halocarbons and SF6
  - This category covers HFCs, PFCs and SF6 emissions from the manufacturing processes of Halocarbons and SF6.
    - 2,513 Gg-CO2/year (0.2 % of Japan's total GHG emissions)
- Consumption of halocarbons and SF6
  - This category covers HFCs, PFCs and SF6 emissions from the manufacturing, utilization and disposal processes.
    - 20,462 Gg-CO2/year (1.6 % of Japan's total GHG emissions)
    - Important category

The characteristic of the Japan's GHG Inventory (Solvent and Other Product Use Sector)

- Overview of Sector
  - CO_2 and N_2O
    - Paint solvents ("NA")
    - Degreasing and dry-cleaning (CO_2;"NE", N_2O;"NA")
    - Other
      - Use of Nitrous Oxide for Anesthesia (N_2O; 160 Gg-CO_2, 0.01 % of total national emissions)
      - Fire Extinguishers (CO_2;"IE", N_2O;"NO")
      - Aerosol Cans (CO_2;"IE", N_2O;"NA")

Question (about the GHG of IPPU Sector in Japan)

- Q; In the "Industrial Process Sector" of Japan's GHG Inventory, are the emissions from the "Mineral Products" category calculated under the "Fuel Combustion" Category?
- A; No. The emissions from the "Iron and Steel Production" category are calculated under the "Fuel Combustion" Category, because the volume of coke used has been included under consumption of fuel in the Fuel Combustion Category.

Way of thinking of sector arrangement in Japan

- The following categories should be calculated under IPPU sector originally but are calculated under an energy sector.
  - The Emissions of CO_2 from "Coke Production"
  - Iron and Steel Production: CO_2 emissions from the oxidization of coke used as a reduction agent
  - Ferroalloys Production: CO_2 emissions from the oxidization of coke used as a reduction agent
  - Aluminum Production: CO_2 emissions from the oxidization of coke used as a reduction agent
  - The CO_2 used in the process of manufacturing foods and drinks, is a by-product gas of petrochemical products, and as such emissions are incorporated into the "Fuel Combustion Sector".

4. Issues of IPPU Sector in Thailand

- I think that the GHG inventory of Industrial process is insufficient.
- I need more detailed breakdown of information.

GHG Emissions from Major Industrial Processes in Thailand; 1994

	CO2 (Gg)	CH4 (Gg)
Cement	14,920.0	
Glass	63.6	
Lime	918.0	
Pulp and Paper	49.3	
Iron and Steel	19.5	
Pertochemicals		0.3
Total	15,970.4	0.3

GHG from Industrial Process (ASEAN Countries)

Thailand	CO2 : 15,970 (Gg) CH4 : 0.31 (Gg) N2O : -
Malaysia	CO2 : 4,973 (Gg) CH4 : - N2O : -
Indonesia	CO2 : 19,120 (Gg) CH4 : - N2O : -
Philippine	CO2 : 10,596 (Gg) CH4 : 0.33 (Gg) N2O : -
Vietnam	CO2 : 3,807 (Gg) CH4 : - N2O : -

5. Practice

- I think that the data collection is generally the most important and difficult in IPPU Sector.
- So, please discuss the sources "Activity Data" in Thailand.
- Worksheets for practice (work and discussion) are distributed.

- ありがとうございました
- ขอบคุณ มาก ครับ/ค่ะ
- Thank you very much

Practice (Not Use)

- The data of Thailand's industrial production are delivered.
- The emission factors of IPCC default value is distributed, too.
- And the worksheets of IPCC guideline are distributed, too.
- Please calculate some emissions of IPPU sector with Tier 1 method.
- Let's proceed with this work while you discuss it in your group.

The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Overview of Agriculture, Forestry and Other Land Use (AFOLU) Sector

21 September, 2010

GHG Inventory
Fumihiko KUWAHARA

Contents of "AFOLU Sector" Training Program

1. Outline of Agriculture, Forestry and Other Land Use (AFOLU) Sector

- Forestry and Other Land Use
  - Emissions/removals from Land-use
- Agriculture
  - Emissions from Livestock
  - Emissions from Manure Management
  - Emissions from Rice cultivation
  - Emissions from Others
- Harvested Wood Products

2006 Guidelines includes:

- CO_2 Emissions/Removals from C-stock changes (Biomass, DOM (Dead Organic Matter) and Soil Pools)
- CO_2 and Non-CO_2 Emissions from Fire in All Managed Land
- N_2O emissions from All Managed Land
- CO_2 emissions from Liming
- CH_4 from Rice Cultivation
- CH_4 and N_2O from Manure Management
- C-stock Changes associated with Harvest Wood Products (HWP)

Introduction of AFOLU

- AFOLU volume was made from experience:
  - Using "Revised 1996 IPCC Guidelines" for nearly 10 years
  - Development in GPG 2000 and GPG 2003 (GPG-LULUCF)
- Combines all land uses in a comprehensive structure
- Updates, expands and improves the methods
- Improved default emissions factors
- Reduces uncertainty and improves consistency and cost-effectiveness of inventories

Principal Improvement over 1996 GL and GPG/GPG-LULUCF (part1)

- 2006 IPCC Guidelines integrate "Agriculture" and "Land Use, Land Use Change and Forestry" Sectors from the GPG/GPG-LULUCF into a single sector "Agriculture Forestry and Other Land Use" (AFOLU) Sector.
- Land use category-based approach that includes all managed land

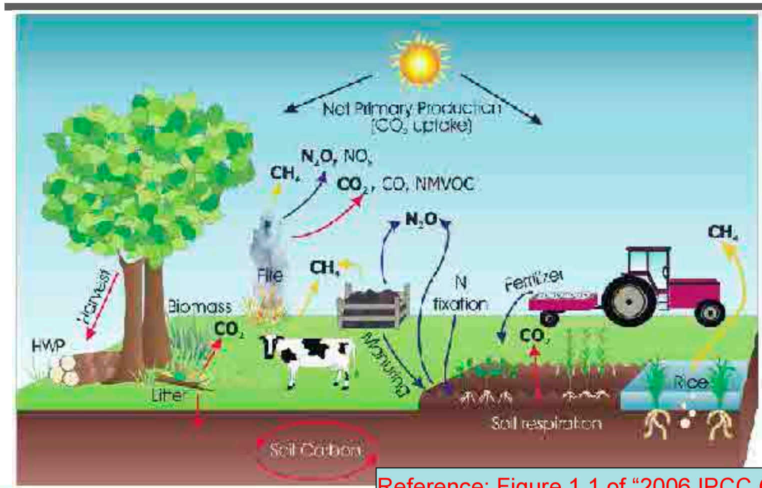
What is "Managed Land"?

- For land use activities (LULUCF and/or AFOLU), how to separate anthropogenic and natural emissions is not clear.
- "Managed Land" is land where human interventions and practices have been applied to perform production, ecological or social functions.

Principal Improvement over 1996 GL and GPG/GPG-LULUCF (part2)

- Reporting emissions and removals from all managed land for consistency.
- Incorporation of key-category analysis
- Three "Tiers" of methods to meet varying circumstances between countries (based on key-category concept)
- Consistent classification of land use categories

The main greenhouse gas emission sources/removals and processes in managed ecosystems



Reference: Figure 1.1 of "2006 IPCC Guidelines"

The general method of calculating the GHG of AFOLU Sector

- First Emissions/Removals from Land (Forestland, Cropland…, etc.)
- Second Emissions from Livestock (Enteric Fermentation, Manure Management)
- Third Emissions from Agriculture Activities (e.g. Biomass Burning, Liming, Urea application, Rice Cultivations, Harvested Wood Products…, etc.)

2. Emissions and Removals from a Land-Use Category

- The Emissions/Removals of CO2 for the AFOLU Sector are estimated in (based on Carbon Stock Changes in ecosystem)
  – Land remaining in the same Land-Use Category
  – Land converted to another Land-Use

Total emissions from a land use category
→ Land remaining in the same land use category
→ Land changed to the land use category from other land use categories

Land-Use Categories

- The emissions/removals from "Land-Use" are estimated according to the following Six Land-Use" Categories
- FL: Forest Land
- CL: Crop Land
- GL: Grass Land
- WL: Wetlands
- SL: Settlements
- OL: Other Land
- These land areas of the first period and the final period are estimated.

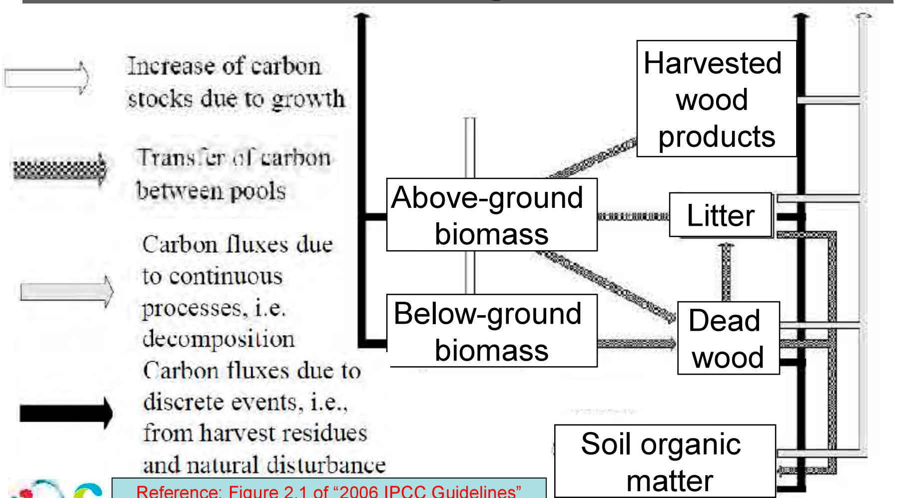
Data Sources of Land-Use

- National sources
  - National Forest/Land Use Inventory, etc
  - Annual Census
  - Periodic Survey
  - Remote Sensing Data
- International sources
  - IPCC Guidelines default data
  - FAO Data
  - International Land Cover Data Sets

Annual Carbon Stock Change for a Land-Use Category

- Carbon Stock Changes are estimated by considering Carbon Cycle Processes between the following Five Carbon Pools.
- AB: Above-ground Biomass
- BB: Below-ground Biomass
- DW: Deadwood
- LI: Litter
- SO: Solid
- These Five Carbon Pools are as follows;

Five Carbon Pools in Different Land Use Categories



Reference: Figure 2.1 of "2006 IPCC Guidelines"

Five Carbon Pools

Biomass	Above-ground biomass	All biomass of living vegetation, both woody and herbaceous, above the soil including stems, stumps, branches, bark, seeds, and foliage.
	Below-ground biomass	All biomass of live root. Fine roots of les than 2mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead organic matter (DOM)	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil.
	Litter	Includes all non-living biomass with a size greater than the limit for soil organic matter and less than the minimum diameter chosen for dead wood, lying dead, in various states of decomposition above or within the mineral or organic soil.
Soil	Soil organic matter	Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series.

How does the carbon stock change add up?

- Annual carbon stock changes for stratum of a land use category ($_{AB}$, $_{BB}$,…=Five Carbon Pool)

$$\Delta C_{LUi} = \Delta C_{AB} + \Delta C_{BB} + \Delta C_{DW} + \Delta C_{LI} + \Delta C_{SO} + \Delta C_{HWP}$$

- Annual carbon stock changes for a land use category (i= denotes a specific stratum or subdivision within the land use category)

$$\Delta C_{LU} = \sum_i \Delta C_{LUi}$$

- Annual carbon stock changes for the entire AFOLU sector estimated ($_{FL}$, $_{CL}$,…=land use category)

$$\Delta C_{AFOLU} = \Delta C_{FL} + \Delta C_{CL} + \Delta C_{GL} + \Delta C_{WL} + \Delta C_{SL} + \Delta C_{OL}$$

Carbon Stock Change Estimation

- Gain-Loss Method (Default Method): Annual Carbon Stock Change in a given Pool as a Function of Gains and Losses
  - Annual Carbon Stock Change = "Annual Gain of Carbon" – "Annual Loss of Carbon"
- Stock-Difference Method: Carbon Stock Change in a given Pool as an Annual Average Difference between Estimates at Two Points in Time
  - Annual Carbon Stock Change = (C_{t2}-C_{t1}) / (t2-t1)
  - C_{t1}: Carbon stock in the pool at time t1
  - C_{t2}: Carbon stock in the pool at time t2

Three Methodological Tiers

- Tier 1: The Simplest to use
  - Default parameter values (emission and stock change factors)
  - Country-specific activity data are needed, but for Tier 1 there are often globally available sources of activity data estimates
- Tier 2: A more accurate approach
  - The same methodological approach as Tier 1
  - Emission and stock change factors are based on country- or region-specific data. Higher temporal and spatial resolution and more disaggregated activity data are typically used.
- Tier 3: Higher order methods
  - Detailed modeling and/or measurement systems driven by data at higher resolution and much lower uncertainties

Some Conditions of Tier 1 method

- Changes in below-ground biomass C stock are assumed to be "ZERO".
- Dead Wood and Litter Pools are often lumped together as "Dead Organic Matter".
- Dead Organic Matter Stock are assumed to be "ZERO" for Non-Forest Land-Use Categories.
  - The Average Transfer Rate into Dead Organic Matter = The Average Transfer Rate out of Dead Organic Matter

Introduction of Representation of Lands

- Countries use various method to obtain data.
- Each of these methods of data collection will yield different type of information, at different reporting frequencies, and with different attributes.
- 2006 IPCC Guidelines is provided on the use of three generic approach.

Representing Land-Use Areas (Three Approaches)

- Approach 1: Total Land-use Area, No Data on Conversions Between Land Use
  - Only the Net Changes in Land-Use Area can be tracked through time.
- Approach 2: Total Land-Use Area, Including Changes between Categories
  - Approach 2 provides an assessment of both the net losses or gains in the area of specific land-use categories and what these conversions represent.
- Approach 3: Spatially-Explicit Land-Use Conversion Data
  - skip

Example: Approach 1 (2006 IPCC Guideline Table3.3)

TABLE 3.3
ILLUSTRATIVE EXAMPLE OF STRATIFICATION OF DATA FOR APPROACH 1

Land-use category/ strata	Initial land area (million ha)	Final land area (million ha)	Net Change in area (million ha)	Status
Forest Land total	18	19	1	
Forest Land (Unmanaged)	5	5	0	Not included in the inventory estimates
Forest Land (temperate continental forest; converted to another land use category)	7	8	1	Estimates should be prepared on the 8 million ha
Forest Land (boreal coniferous)	6	6	0	No land-use conversion. Could require stratification for different management regimes etc.
Grassland total	84	82	2	
Grassland (Unimproved)	65	63	-2	Fall in area indicates land use conversion. Could require stratification for different management regimes etc.
Grassland (Improved)	19	19	0	No land-use conversion. Could require stratification for different management regimes etc.
Cropland total	31	29	-2	Fall in area indicates land-use conversion. Could require stratification for different management regimes etc.
Wetlands total	0	0	0	
Settlements total	6	8	3	
Other Land total	2	2	0	Unmanaged - not in inventory estimates
TOTAL	140	140	0	Note: areas should reconcile

Note: "Initial" is the category at a time previous to the date for which the assessment is made and "Final" is the category at the date of assessment. Activities for which location data are not available should be identified by further sub-categorisation of an appropriate land category.

Example: Approach 2 (2006 IPCC Guideline Table3.6)

TABLE 3.6
SIMPLIFIED LAND-USE CONVERSION MATRIX FOR APPROACH 2 EXAMPLE

Net land-use conversion matrix

Final \ Initial	F	G	C	W	S	O	*Final sum*
F	15	3	1				*19*
G	2	80					*82*
C			29				*29*
W				0			*0*
S	1	1	1		5		*8*
O						2	*2*
Initial sum	*18*	*84*	*31*	*0*	*5*	*2*	*140*

Note:
F = Forest Land, G = Grassland, C = Cropland, W = Wetlands,
S = Settlements, O = Other Land
Numbers represent area units (Mha in this example).

Land-Use Categories, Carbon Pools (Estimated GHG Emissions) (Simplest: Tier1 & Approach1; Part1)

	AB	BB	DW	LI	SO
FL -> FL	Should estimate	Should estimate	=0	=0	Should estimate
Oth -> FL	Should estimate	Should estimate	Increase linearly from zero		Should estimate
CL -> CL	Should estimate	Should estimate	=0	=0	Should estimate
Oth -> CL	Carbon Stock after conversion = 0		Carbon Stock before conversion is zero.		Should estimate
GL -> GL	Should estimate	Should estimate	=0	=0	Should estimate
Oth -> GL	Should estimate	Should estimate	Carbon Stock before conversion is zero.		Should estimate

Land-Use Categories, Carbon Pools (Estimated GHG Emissions) (Simplest: Tier1 & Approach1; Part2)

	AB	BB	DW	LI	SO
WL -> WL	No methodologies are provided.				
Oth -> WL	The carbon stock after conversion is zero. The carbon stock before conversion need to estimate				No Guidance
SL -> SL	No change		At equilibrium No need to estimate		No change
Oth -> SL	Zero after conversion		All non-forest land are assumed to be zero.		Should estimate
OL -> OL	No Guidance				
Oth -> OL	The carbon stock after conversion is zero.		No emissions or removals		Zero after conversion

Land-Use Categories, Carbon Pools (Estimated GHG Emissions) (Japan's Case: Approach2; Part1)

	AB	BB	DW	LI	SO
FL -> FL	Tier2	Tier2	Tier3	Tier3	Tier3
Oth -> FL	IE	IE	Tier3	Tier3	Tier3
CL -> CL	NA	NA	NA	NA	NE
FL -> CL	Tier2	Tier2	Tier2	Tier2	Tier2
Oth -> CL	Tier1	Tier1	NE	NE	Tier2
GL -> GL	NE & NA				
FL -> GL	Tier2	Tier2	Tier2	Tier2	Tier2
Oth -> GL	Tier1	Tier1	NE	NE	Tier2

- IE = "Included Elsewhere", NA = "Not Applicable", NE = "Not Estimated",
- CS = "Country Specific", "-" = This category is not considered in according to GPG-LULUCF

Land-Use Categories, Carbon Pools (Estimated GHG Emissions) (Japan's Case: Approach2; part2)

	AB	BB	DW	LI	SO
WL -> WL	NE,NO	NE,NO	NE,NO	NE,NO	NE,NO
Oth -> WL	Tier2	Tier2	Tier1	Tier1	Tier1
SL -> SL	Tier1	Tier1	IE	CS	-
Oth -> SL	Tier1	Tier1	Tier2	Tier2	-
OL -> OL	-	-	-	-	-
FL -> OL Oth -> OL	Tier2	Tier2	Tier1	Tier1	NE

- IE = "Included Elsewhere", NA = "Not Applicable", NE = "Not Estimated",
- CS = "Country Specific", "-" = This category is not considered in according to GPG-LULUCF

Questions (about Land Use)

- Q1: Please describe the difference between "Three Approaches" and "Three Tiers".
- A1: Tree Approaches are the Representation of Land-Use Area.
- A1: Tree Tiers are the Methods of GHG Emissions from Land-Use.
- Q2: Are the GHG emissions from the land-use categories estimated by the flow of CO2?
- A2: No. Not CO2, but carbon.

3. Practice1 (calculation condition)

- Steps for estimating change in carbon stocks in biomass using the default methods
- Condition; (**assumption**)
  - Climate: Tropical (Please check!)
  - Ecological zone: Tropical dry forest (Please check!)
  - The area of Forest Land Remaining Forest Land : **100,000** (ha) (Temporary set value)
  - It is a 25-year-old hardwoods, average-ground growing stock volume is 40 m^3 ha^{-1}. (Please check!)
  - The merchantable round wood harvest over bark(H) is **1,000** m^3 yr^{-1}.
  - Whole tree fuel wood removal is **500** m^3 yr^{-1}. (Temporary set value)
  - Area insect disturbance is **2,000** ha yr^{-1} with above- biomass affect 4.0 tonne d.m. ha^{-1}. (Temporary set value)

Practice1 (Climate Domains, Climate Regions, Ecological Zones)

TABLE 4.1
CLIMATE DOMAINS (FAO, 2001), CLIMATE REGIONS (CHAPTER 3), AND ECOLOGICAL ZONES (FAO, 2001)

Climate domain: Domain	Climate domain: Domain criteria	Climate region	Ecological zone: Zone	Code	Zone criteria
Tropical	all months without frost; in marine areas, temperature >18°C	Tropical wet	Tropical rain forest	TAr	wet: ≤ 3 months dry, during winter
		Tropical moist	Tropical moist deciduous forest	TAwa	mainly wet: 3-5 months dry, during winter
		Tropical dry	Tropical dry forest	TAWb	mainly dry: 5-8 months dry, during winter
			Tropical shrubland	TBSh	semi-arid: evaporation > precipitation
			Tropical desert	TBWh	arid: all months dry
		Tropical montane	Tropical mountain systems	TM	altitudes approximately >1000 m, with local variations

Practice1 (Annual gain in Biomass)

- Annual Increase in Biomass Carbon Stocks:

$$\Delta C_G = \sum_{i,j} \left(A_{i,j} \bullet G_{TOTAL\,i,j} \bullet CF_{i,j} \right)$$

- Average Annual Increment in Biomass :

$$G_{TOTAL} = \sum \{ G_W \bullet (1 + R) \}$$

  - Gw = **1.5** tonnes d.m. ha^{-1} yr^{-1} (← Table 4.9)
  - R = **0.28** tonne d.m. (tonne d.m.)$^{-1}$: Above-ground biomass > 20 tonnes ha^{-1} (Tropical dry forest) (← Table 4.4 with reference to Table 4.7)
  - G_{total} = 1.5 x (1 + 0.28) = **1.92** (tonnes d.m. ha^{-1} yr^{-1})
  - CF = **0.47** tonne C (tonne d.m.)$^{-1}$: (← Table 4.3)

- ΔC_G = 100,000 (ha) x 1.92 (tonnes d.m. ha^{-1} yr^{-1}) x 0.47 (tonne C (tonne d.m.)$^{-1}$)=**90,240** tonnes C yr^{-1}

Practice1 (Table 4.9 Above-ground net Biomass Growth in Natural Forests (Tropical dry forest))

Continent		Reference
Africa (≤20 y)	2.4	IPCC, 2003
Africa (>20 y)	1.8	IPCC, 2003
North and South America (≤20 y)	4.0	IPCC, 2003
North and South America (>20 y)	1.0	IPCC, 2003
Asia (continental ≤20 y)	6.0	IPCC, 2003
Asia (continental >20 y)	1.5	IPCC, 2003
Asia (insular ≤20 y)	7.0	IPCC, 2003
Asia (insular >20 y)	2.0	IPCC, 2003

Practice1 (Table 4.4 Ration Below-Ground Biomass to Above-Ground Biomass (R))

Ecological Zone	Above-ground Biomass	R
Tropical rainforest		0.37
Tropical moist deciduous forest	Above-ground biomass <125 tonnes ha^{-1}	0.20(0.09 - 0.25)
	Above-ground biomass >125 tonnes ha^{-1}	0.24(0.22 - 0.33)
Tropical dry forest	Above-ground biomass <20 tonnes ha^{-1}	0.56(0.28 - 0.68)
	Above-ground biomass >20 tonnes ha^{-1}	0.28(0.27 - 0.28)
Tropical shrubland		0.40
Tropical mountain system		0.27(0.27 - 0.28)

Practice1 (Table 4.3 Carbon Fraction of aboveground forest biomass)

TABLE 4.3
CARBON FRACTION OF ABOVEGROUND FOREST BIOMASS

Domain	Part of tree	Carbon fraction, (CF) [tonne C (tonne d.m.)$^{-1}$]	References
Default value	All	0.47	McGroddy et al., 2004
Tropical and Subtropical	All	0.47 (0.44 - 0.49)	Andreae and Merlet, 2001; Chambers et al., 2001; McGroddy et al., 2004; Lasco and Pulhin, 2003
	wood	0.49	Feldpausch et al., 2004
	wood, tree d < 10 cm	0.46	Hughes et al., 2000
	wood, tree d ≥ 10 cm	0.49	Hughes et al., 2000
	foliage	0.47	Feldpausch et al., 2004
	foliage, tree d < 10 cm	0.43	Hughes et al., 2000
	foliage, tree d ≥ 10 cm	0.46	Hughes et al., 2000
Temperate and Boreal	All	0.47 (0.47 - 0.49)	Andreae and Merlet, 2001; Gayoso et al., 2002; Matthews, 1993; McGroddy et al., 2004
	broad-leaved	0.48 (0.46 - 0.50)	Lamlom and Savidge, 2003
	conifers	0.51 (0.47 - 0.55)	Lamlom and Savidge, 2003

Source: 2006 IPCC Guideline Volume 4 Figure 4.3

Practice1 (Biomass loss)

- Biomass Loss: (Equation 2.11)
- ΔC_L = $L_{wood\text{-}removals}$ + $L_{fuelwood}$ + $L_{disturbance}$
- Wood removal: (Equation 2.12)
- $L_{wood\text{-}removals}$ = {H x $BCEF_R$ x (1+R) x CF}
- Fuelwood removal: (Equation 2.13)
- $L_{fuelwood}$ = [{FG_{trees} x $BCEF_R$ x (1+R)} + FG_{part} x D] x CF
- Disturbance: (Equation 2.14)
- $L_{disturbance}$ = {$A_{disturbance}$ x B_W x (1+R) x CF x fd}

Practice1 (Wood removal)

- $L_{wood\text{-}removals}$ = {H x $BCEF_R$ x (1+R) x CF}
  - H = **1,000** (m^3 yr^{-1}) : Wood Harvest
  - $BCEF_R$ = **2.11** tonnes d.m. m^{-3} yr^{-1} (← Table 4.5)
  - Default BF = **0.1** tonne d.m. (tonne d.m.)$^{-1}$
  - R = **0.28** tonne d.m. (tonne d.m.)$^{-1}$: Above-ground biomass > 20 tonnes ha^{-1} (Tropical dry forest) (← Table 4.4, for above-ground biomass refer to Table 4.17)
  - CF = **0.47** tonne C (tonne d.m.)$^{-1}$: (← Table 4.3)
- $\Delta L_{wood\text{-}removals}$ = 1,000 (m^3 yr^{-1}) x 2.11 (tonnes d.m. m^{-3}) x (1 + 0.28 + 0.1) x 0.47 (tonne C (tonne d.m.)$^{-1}$) = **1,368.55** tonnes C yr^{-1}

Practice1 (Table 4.5 Default Biomass Conversion and Expansion Factors (Growing Stock Level))

Hardwoods	Mediterranean, dry tropical, subtropical Growing Stock Level (m^3)			
	<20	21-40	41-100	>100
$BCEF_S$	5.0	1.9	0.8	0.66
$BCEF_I$	1.5	0.5	0.55	0.66
$BCEF_R$	5.55	2.11	0.89	0.73

- $BCEF_S$: Stock Volume to above-ground biomass
- $BCEF_I$: Conversion of net annual increment
- $BCEF_R$: Conversion of wood and fuelwood removal volume to above-ground biomass removal

Practice1 (Fuelwood removal)

- $L_{fuelwood}$ = [{FG_{trees} x $BCEF_R$ x (1+R)} + FG_{part} x D] x CF
  - FG_{trees} = 500 (m^3 yr^{-1});annual volume of fuelwood removals of whole trees
  - FG_{part} = **0** (m^3 yr^{-1}) (assumption) ; annual volume of fuelwood removal as tree parts
  - $BCEF_R$ = **2.11** tonnes d.m. m^{-3} yr^{-1} (← Table 4.5)
  - R = **0.28** tonne d.m. (tonne d.m.)$^{-1}$: Above-ground biomass > 20 tonnes ha^{-1} (Tropical dry forest) (← Table 4.4, for above-ground biomass refer to Table 4.17)
  - CF = **0.47** tonne C (tonne d.m.)$^{-1}$: (← Table 4.3)
- $\Delta L_{wood\text{-}removals}$ = 500 (m^3 yr^{-1}) x 2.11 (tonnes d.m. m^{-3}) x (1 + 0.28) x 0.47 (tonne C (tonne d.m.)$^{-1}$) = **634.69** tonnes C yr^{-1}

Practice1 (Table 4.7 Above-Ground Biomass in Forests)

TABLE 4.7
ABOVE-GROUND BIOMASS IN FORESTS

Domain	Ecological zone	Continent	Above-ground biomass (tonnes d.m. ha^{-1})	References
Tropical	Tropical rain forest	Africa	310 (130-510)	IPCC, 2003
		North and South America	300 (120-400)	Baker *et al.*, 2004a; Hughes *et al.*, 1999
		Asia (continental)	280 (120-680)	IPCC, 2003
		Asia (insular)	350 (280-520)	IPCC, 2003
	Tropical moist deciduous forest	Africa	260 (160-430)	IPCC, 2003
		North and South America	220 (210-280)	IPCC, 2003
		Asia (continental)	180 (10-560)	IPCC, 2003
		Asia (insular)	290	IPCC, 2003
	Tropical dry forest	Africa	120 (120-130)	IPCC, 2003
		North and South America	210 (200-410)	IPCC, 2003
		Asia (continental)	130 (100-160)	IPCC, 2003
		Asia (insular)	160	IPCC, 2003
	Tropical shrubland	Africa	70 (20-200)	IPCC, 2003
		North and South America	80 (40-90)	IPCC, 2003
		Asia (continental)	60	IPCC, 2003
		Asia (insular)	70	IPCC, 2003
	Tropical mountain systems	Africa	40-190	IPCC, 2003
		North and South America	60-230	IPCC, 2003
		Asia (continental)	50-220	IPCC, 2003
		Asia (insular)	50-360	IPCC, 2003

Source: 2006 IPCC Guideline Volume 4 Figure 4.7

Practice1 (Annual Carbon Loss in Biomass due to Disturbance)

- $L_{disturbance}$ = {$A_{disturbance}$ x B_W x (1+R) x CF x fd}
  - $A_{disturbance}$ = 2,000 (ha yr^{-1})
  - B_W = **1.5** (m^3 yr^{-1}) ; (← Table 4.9)
  - R = **0.28** tonne d.m. (tonne d.m.)$^{-1}$: Above-ground biomass > 20 tonnes ha^{-1} (Tropical dry forest) (← Table 4.4, for above-ground biomass refer to Table 4.17)
  - CF = **0.47** tonne C (tonne d.m.)$^{-1}$: (← Table 4.3)
  - fd = **0.3** (m^3 yr^{-1}) (assumption) ;
- $\Delta L_{wood-removals}$ = 2,000 (ha yr^{-1}) x 1.5 (tonnes d.m. m^{-3}) x (1 + 0.28) x 0.47 (tonne C (tonne d.m.)$^{-1}$) x 0.3 = **541.44** tonnes C yr^{-1}

Practice1 (Annual Change in carbon stock in biomass)

- Annual Change in Carbon Stock in Biomass : $\Delta C_B = \Delta C_G - \Delta C_L$
- ΔC_B = 90,240 tonnes C yr^{-1} –
- (1,368.55 tonnes C yr^{-1} +
- 634.69 tonnes C yr^{-1} +
- 541.44 tonnes C yr^{-1})
- = **87,695.32** tonnes C yr^{-1}

  ;removal sources

Japan's Case Study

- I show the Japan's Emissions/Removals of GHG from the Forest Land.
- I would like you to understand the steps of calculation of the GHG emissions/removals from Forest land from showing the specific example.

Japan's Case Study 1 (Carbon stock change in Living Biomass in Forest land remaining Forest land)

- Estimation Method (Stock-Difference Method)

$$\Delta C_{LB} = \sum_k \{(C_{t2} - C_{t1})/(t_2 - t_1)\}_k$$

ΔC_{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

$$C = \sum_j \{V_j \cdot D_j \cdot BEF_j] \cdot (1+R_j) \cdot CF\}$$

C : carbon stock in living biomass (t-C)
V : merchantable volume (m^3)
D : wood density (t-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

$$V = \sum_{m,j} (A_{m,j} \cdot v)$$

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

Japan's Case Study 1 (Yield Table used to estimate merchantable volume)

Table 7-6 Yield tables used to estimate merchantable volume

Tree species			Yield tables: Private Forest	Yield tables: National Forest
Intensively managed forests	Conifer	Japanese cedar, Hinoki cypress, Japanese larch	New Yield Tables	Yield tables developed by Regional Forest Offices
		Other conifer	Yield tables developed by prefectures	
	Broad leaf			
Semi-natural forests				

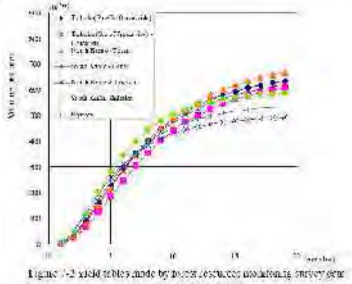


Figure 7-2 Yield tables made by forest resources monitoring survey data (Japanese cedar : 7 areas)

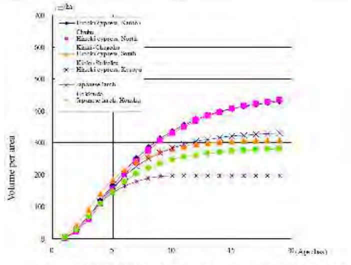


Figure 7-3 Yield tables made by forest resources monitoring survey data (Hinoki cypress : 4 areas, Japanese larch : 2 areas)

Japan's Case Study 1 (Biomass Expansion Factor & Root-to-Shoot Ratio)

- BEFs were calculated for two age classes (<20, >21), because it was identified that BEFs differ between young forest and mature forest.
- These Root-to-Shoot Ration values were established for each tree species, because root-to-shoot ration was not correlated with forest age.

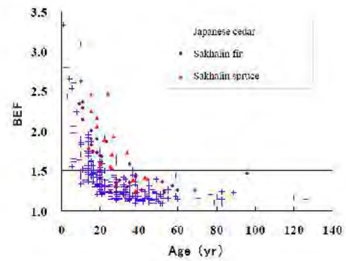


Figure 7-4 Biomass expansion factor related with forest age

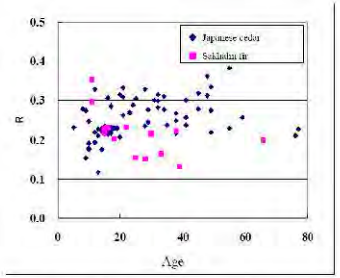


Figure 7-5 Root-to-shoot ratio (R), tree species, forest age

Japan's Case Study 1 (BEF, Root-Shoot Ration, Wood Density, Part1)

Table 7-7 BEF, Root-Shoot ratio, wood density for tree species provided in Forest register

		BEF ≦20	BEF >20	R	D	CF	Note
Conifer trees	Japanese cedar	1.57	1.23	0.25	0.314		
	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

Japan's Case Study 1 (BEF, Root-Shoot Ration, Wood Density, Part2)

Broad leaf trees	Japanese beech	1.58	1.32	0.26	0.573	0.5	
	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	1.23	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

Japan's Case Study 1 (Activity Data Source)

Table 7-8 Classifications in *Survey on Status Forest Resources* and *National Forest resources 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 Japanese black pine		Japanese beech Oak (evergreen tree)
Japanese larch	Japanese larch		Japanese chestnut
Sakhalin fir	Sakhalin fir		Japanese poplar
Yezo spruce	Yezo spruce		Alder
	Sakhalin spruce		Japanese elm
Other conifer	Sawara cypress Hiba arborvitae	Other broad leaf	Japanese zelkova Cercidiphyllum
	Momi fir		Japanese big-leaf magnolia
	Japanese hemlock Japanese umbrella pine Japanese yew		Maple tree Amur cork Japanese lime
	Ginkgo		Linden
	Exotic conifer trees Other needle leaf		Kalopanax Paulownia Exotic broad leaf trees Other broad leaf

Japan's Case Study 1 (Activity Data)

- The area of "Forest Land Remaining Forest Land" in a certain year is estimate by subtracting the Cumulative total area of "Land converted to Forest Land" during the past 20 years from the total area of "Forest Land" in the year subject to estimation. In addition, all area of "Land converted to Forest Land" are assumed to be intensively managed forests.

Table 7-9 Area of Forest land remaining Forest land

Category	Unit	1990	1995	2000	2005	2006	2007	2008
Forest land remaining Forest land	kha	24,807.4	24,826.1	24,825.2	24,954.0	24,950.2	24,948.3	24,936.6
Intensively managed forests	kha	10,144.9	10,284.8	10,279.7	10,298.3	10,296.2	10,285.9	10,275.9
Semi-natural forests	kha	13,354.5	13,220.3	13,195.2	13,315.7	13,306.2	13,321.5	13,333.5
Cut-over forests and lesser stocked forests	kha	1,159.0	1,171.0	1,197.4	1,186.0	1,193.1	1,184.7	1,170.8
Bamboo	kha	149.0	150.0	152.9	154.0	154.7	156.2	156.4

Source: Forest Status Survey (Forest Agency)

Japan's Case Study 2 (Carbon Stock Change in Dead Organic Matter and Soil in Forest land remaining Forest land)

- 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 the emissions/removals of all forest management types are the annual changes in total carbon stocks in dead wood, litter and soil.

$$\Delta C_{dls} = \sum_{k,m,j} \left(A_{k,m,j} \times (d_{k,m,j} + l_{k,m,j} + s_{k,m,j}) \right)$$

ΔC_{dls} : 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
m : Age class or forest age
j : Tree species

Japan's Case Study 2 (CENTURY-jfos Model)

- 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 condition.

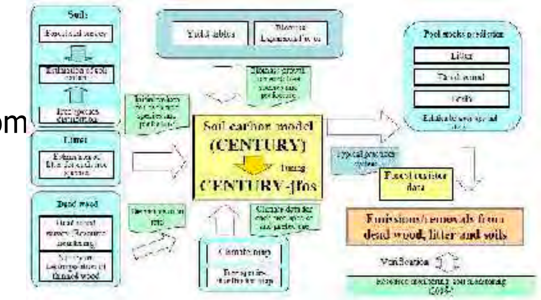


Figure 7-5 Estimation of removals in dead wood, litter and soils

Japan's Case Study 2 (Standard Soil Carbon Stock used for the CENTURY-jfos Model) part1

Table 7-10 Standard Soil Carbon Stocks used for the CENTURY-jfos Model

(Kg-C/m^2 [30 cm depth])

Prefecture	Tree Species							
	Japanese Cedar	Hinoki Cypress	Pine species	Japanese Larch	Sakhaline Fir	Sakhaline Spruce	Broad Leaf Trees	Other Conifer
Hokkaido	98.0	NA	100.6	91.0	88.0	93.7	91.0	89.4
Aomori	92.1	NA	94.3	83.3	109.1	NA	89.0	89.8
Iwate	89.5	93.6	92.7	93.9	98.1	NA	91.3	93.3
Miyagi	86.1	70.8	78.5	90.3	110.9	NA	82.8	80.5
Akita	81.1	NA	72.4	81.0	108.5	NA	82.6	79.6
Yamagata	83.2	79.7	68.0	81.0	97.4	NA	74.4	76.9
Fukushima	84.3	83.7	81.1	89.3	108.6	NA	81.4	85.0
Ibaraki	84.3	83.4	97.6	NA	NA	NA	91.2	90.8
Tochigi	83.0	86.1	91.6	100.6	133.4	NA	93.1	96.4
Gunma	88.7	88.3	93.9	95.1	98.1	NA	86.5	93.9
Saitama	81.3	82.4	96.2	106.8	NA	NA	85.8	94.7
Chiba	93.9	85.7	65.6	NA	NA	NA	84.6	76.4
Tokyo	79.2	81.6	85.7	94.7	NA	NA	63.9	84.3
Kanagawa	91.9	99.8	89.8	NA	NA	NA	94.9	99.1
Niigata	83.9	51.3	63.4	86.7	133.0	NA	85.3	86.9
Toyama	90.3	NA	72.5	88.5	106.0	NA	94.5	100.2
Ishikawa	82.7	80.2	70.2	NA	133.4	NA	86.6	71.3
Fukui	88.7	85.8	79.8	NA	NA	NA	90.1	80.6

Japan's Case Study 2 (Standard Soil Carbon Stock used for the CENTURY-jfos Model) part2

Yamanashi	93.0	93.9	98.0	99.3	NA	NA	93.9	95.6
Nagano	102.1	100.5	96.0	108.4	106.0	NA	97.9	103.3
Gifu	100.5	94.8	79.1	99.6	107.8	NA	95.8	93.9
Shizuoka	94.6	96.7	69.1	90.7	NA	NA	90.0	93.7
Aichi	91.2	85.0	60.1	NA	NA	NA	78.5	77.2
Mie	92.1	84.4	63.8	97.1	NA	NA	78.7	80.5
Shiga	83.5	73.0	59.6	NA	NA	NA	79.5	65.8
Kyoto	74.0	67.4	63.3	NA	NA	NA	66.4	64.6
Osaka	73.9	74.0	60.9	NA	NA	NA	67.5	66.0
Hyogo	88.3	71.8	53.0	123.6	NA	NA	63.4	61.9
Nara	79.6	69.8	65.5	NA	NA	NA	73.4	69.4
Wakayama	72.1	70.5	58.2	NA	NA	NA	62.8	69.9
Tottori	73.8	74.9	75.6	121.2	NA	NA	72.3	75.4
Shimane	69.0	66.6	61.2	77.3	NA	NA	64.6	63.2
Okayama	80.3	73.7	51.4	121.2	NA	NA	65.2	63.6
Hiroshima	74.0	71.8	54.0	71.2	NA	NA	65.0	58.7
Yamaguchi	64.9	60.9	49.3	NA	NA	NA	55.2	54.8
Tokushima	72.9	63.7	63.6	NA	NA	NA	66.7	63.7
Kagawa	57.7	61.9	56.6	NA	NA	NA	57.2	57.7
Ehime	80.1	75.1	63.2	85.4	NA	NA	67.4	74.1
Kochi	81.4	76.1	73.8	NA	NA	NA	74.1	76.2
Fukuoka	97.3	88.9	77.5	NA	NA	NA	86.5	88.3
Saga	83.6	83.0	69.1	NA	NA	NA	79.6	82.9
Nagasaki	82.9	84.5	82.6	NA	NA	NA	78.9	84.5
Kumamoto	103.7	96.0	79.3	NA	NA	NA	93.5	95.6
Oita	109.9	100.5	108.3	130.3	NA	NA	99.1	101.4
Miyazaki	106.1	102.0	93.7	NA	NA	NA	98.0	99.6
Kagoshima	108.4	102.4	75.7	NA	NA	NA	90.8	97.0
Okinawa	58.5	NA	58.9	NA	NA	NA	58.0	58.5

Japan's Case Study 1&2 (Results of Emission and Removals in Forest Land)

- Japan's Emissions and Removals in Forest Land resulting from Carbon Stock Changes

Table 7-5 Emissions and Removals in Forest land resulting from Carbon Stock Changes

Gas	Category	Carbon pool	Unit	1990	1995	2000	2005	2006	2007	2008
CO_2	5.A. Forest land	Total	Gg-CO_2	-72,427.5	-79,685.0	-83,475.8	-87,513.4	-83,399.3	-82,873.5	-79,934.3
		Living Biomass	Gg-CO_2	-72,020.6	-79,509.0	-83,359.6	-86,537.6	-81,747.4	-81,333.1	-76,505.5
		Dead Wood	Gg-CO_2	-340.9	-168.9	-121.3	1,234.9	778.2	826.7	188.1
		Litter	Gg-CO_2	-147.9	-73.3	-52.6	-619.5	-826.6	-804.5	-720.6
		Soil	Gg-CO_2	81.3	66.1	57.8	-1,591.3	-1,603.5	-1,562.6	-2,896.2
	5.A.1. Forest land remaining Forest land	Total	Gg-CO_2	-72,020.6	-79,509.0	-83,359.6	-87,433.5	-83,324.6	-82,803.9	-79,869.3
		Living Biomass	Gg-CO_2	-72,020.6	-79,509.0	-83,359.6	-86,537.6	-81,747.4	-81,333.1	-76,505.5
		Dead Wood	Gg-CO_2	NA,NE	NA,NE	NA,NE	1,326.1	864.5	908.6	265.6
		Litter	Gg-CO_2	NA,NE	NA,NE	NA,NE	-580.0	-789.1	-769.0	-687.0
		Soil	Gg-CO_2	NA,NE	NA,NE	NA,NE	-1,642.1	-1,652.6	-1,610.5	-2,942.5
	5.A.2. Land converted to Forest land	Total	Gg-CO_2	-405.9	-176.0	-116.2	-79.9	-74.6	-69.6	-65.0
		Living Biomass	Gg-CO_2	IE	IE	IE	IE	IE	IE	IE
		Dead Wood	Gg-CO_2	-340.9	-168.9	-121.3	-91.1	-86.3	-81.9	-77.6
		Litter	Gg-CO_2	-147.9	-73.3	-52.6	-39.5	-37.4	-35.5	-33.7
		Soil	Gg-CO_2	81.3	66.1	57.8	50.8	49.1	47.9	46.2

5. Agriculture

- Emissions from Livestock and Manure Management
- N2O Emissions from Managed Soils, and CO2 Emissions from Lime and Urea Application
- CH4 Emissions from Rice Cultivation

Emissions from Livestock and Manure Management

- Enteric Fermentation: CH_4
  - Cattle are an important source of CH_4
- Manure Management: CH_4 and N_2O
  - CH_4: Enteric Fermentation > Manure Management
- Required Data
  - Annual Populations (All Tier)
  - Feed Intake and Characterisation (Higher Tier method)

Representative Livestock Categories

- Mature Dairy Cow or Mature Dairy Buffalo
- Other Mature Cattle or Mature Non-dairy Buffalo
- Growing Cattle or Growing Buffalo
- Mature Ewes
- Other Mature Sheep
- Growing Lambs
- Mature Swine
- Growing Swine
- Chickens
- Turkeys
- Ducks
- Others (Camels, Mules and Asses, Rabbits, Horse, …etc.)

Why are these detailed livestock subcategories set up? (part1)

- Depending on the level of detail in the emissions estimation method, subcategories can be further classified based on animal or feed characteristics.
- For example, growing/ fattening cattle could be further subdivided into those cattle that are fed a high-grain diet and housed in dry lot vs. those cattle that are grown and finished solely on pasture.

Why are these detailed livestock subcategories set up? (part2)

- For example, growing lambs could be further segregated into lambs finished on pasture vs. lambs finished in a feedlot.
- For example, growing swine could be further subdivided into growing swine housed in intensive production facilities vs. swine that are grown under free-range conditions.
- For example, poultry could be divided on the basis of production under confined or free-range conditions.

Tier 1 method (CH4 Emissions from Enteric Fermentation)

- Tier 1: CH4 Emissions = "EF_T" x "$N_T/10^6$"
  - EF_T : Emission Factor for the defined Livestock population (kg CH4 $head^{-1}$ yr^{-1})
  - N_T: the Number of Head of Livestock species / category T"
  - T: Species/category of Livestock

Tier 1 method (CH4 Emissions from Manure Management)

- Required Data: Livestock Population, Climate Region or Temperature
- Tier 1: CH4 Emissions = "EF_T" x "$N_T/10^6$"
  - EF_T : Emission Factor by Temperature for the defined Livestock population (kg CH4 $head^{-1}$ yr^{-1})
  - N_T: the Number of Head of Livestock species / category T"
  - T: Species/category of Livestock

Question (about Livestock)

- Q: We should directly use the "Annual Average Population of Livestock", as an Activity Data, from official national statistics. (Is it true or false?)
- A: False, exactly we should not directly use them, because some animals (e.g. meat animals, such as broilers, turkeys, beef cattle, and market swine) are alive for only part of a complete year.
  - Annual Average Population = "Days_alive" x "Number of animals produced annually" / 365 (e.g. "Days_alive" of Broiler chickens is "60 days")

Tier 1 method (Direct N2O Emissions from Manure Management)

- Required Data: Livestock Population, Default EF, Default Nitrogen Excretion Data, Default Manure Management System Data
- Tier 1: N2O Emissions = ("N_T" x "Nex_T" x "$MS_{T,S}$") x "EF_S" x 44/28
  - N_T: the Number of Head of Livestock species / category T
  - Nex_T: Annual Average N excretion (kg N $animal^{-1}$ yr^{-1})
  - $MS_{T,S}$: Fraction of Total Annual Nitrogen Excretion for each Live stock species/category T that is managed in manure
  - EF_S : Emission Factor for Manure Management System S (kg N2O-N / kg-N)
  - S: Manure Management System
  - T: Species/category of Livestock
  - 44/28: Conversion of N2O-N emissions to N2O emissions

Indirect N2O Emissions from Manure Management

- Indirect Emissions result from Volatile Nitrogen Losses that occur primarily in the Forms of NH3 and NOx.
- Tier 1 method is analogous to the direct N2O Emissions from Manure Management.
- Examples of methods of this sub-category are skipped.

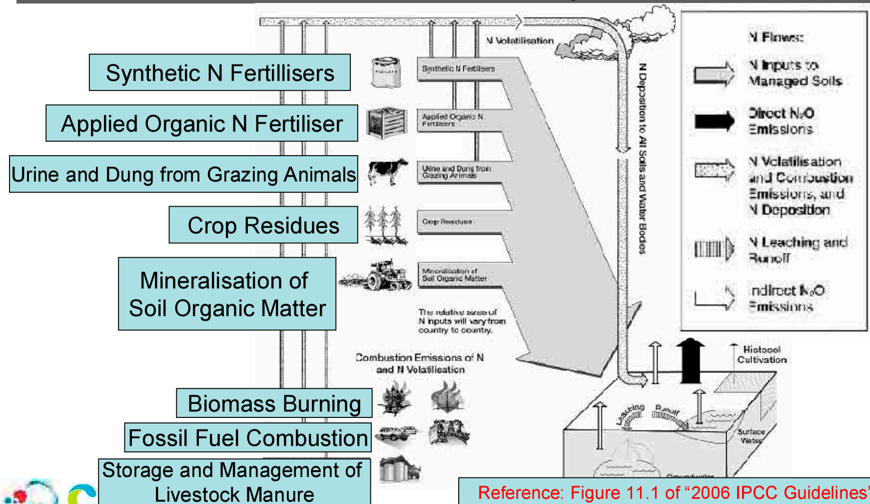
N2O Emission from Managed Soils, and CO2 Emissions from Lime and Urea Application

- N2O Emissions from Managed Soils
  - Nitrous oxide is produced naturally in soils through the processes of nitrification and denitrification.
- CO2 Emissions from Liming
  - Liming leads to CO2 emissions because the carbonate limes dissolve and release bicarbonate.
- CO2 Emissions from Urea Fertilization
  - Urea is converted into Ammonium, Hydroxyl Ion and Bicarbonate. Bicarbonate evolves into CO2 and water.

Tier 1 method (N2O Emission from Managed Soils, and CO2 Emissions from Lime and Urea Application)

- N2O Emissions from Managed Soils
  - N2O Emissions = "Emissions from N inputs to managed soils" + "Emissions from managed organic soils" + "Emissions from Urine and dung inputs to grazed soils"
- CO2 Emissions from Liming
  - CO2-C Emissions = "Annual Amount of Calcic Limestone" x "$EF_{Limestone}$" + "Annual Amount of Dolomite" x "$EF_{Dolomite}$"
- CO2 Emissions from Urea Fertilization
  - CO2-C Emissions = "Annual Amount of Urea Fertilisation" x "EF"

Schematic Diagram Illustrating the Source and Pathways of N



Reference: Figure 11.1 of "2006 IPCC Guidelines"

New Methodology of Rice Cultivation

- New guidelines (from 1996 GL, and GPG2000)
- (i) Revision of emission and scaling factors
- (ii) Use of daily EF– instead of seasonal –
- (iii) New scaling factors for water regime
- (iv) Inclusion of Tier 3 approach in line

The study results of Japanese Researchers of National Institute for Agro-Environmental Sciences

CH4 Emissions from Rice Cultivation

$$CH4_{Rice} = \sum_{i,j,k} \left(EF_{i,j,k} \cdot t_{i,j,k} \cdot A_{i,j,k} \cdot 10^{-6} \right)$$

$CH4_{Rice}$: annual methane emissions from rice cultivation, Gg CH4 yr^{-1}

$EF_{i,j,k}$: a daily emission factor for i, j, and k conditions, kg CH4 ha^{-1} day^{-1}

$t_{i,j,k}$: cultivation period of rice for i, j, and k conditon, day

$A_{i,j,k}$: anual harvested area of rice for i, j, and k conditions, ha yr^{-1}

i, j, k : represent different ecosystems, water regimes, type and amout of organic amendments, and other conditions under which CH4 emissions from rce may bary

- Revised 1996 IPCC Guidelines
- $CH4_{Rice}$ = EF x A x 10^{-12}
- EF: Emission Factor, A: annual harvested area

Practice2

- Q1: How long are the cultivation periods of rice in Thailand?
- Q2: Please calculate the CH4 emissions from Rice Cultivation, using the Tier 1 (Default) method of "Revised 1996 IPCC Guidelines".
- Q3: And please calculate the CH4 emissions from Rice Cultivation, using the Tier 1 (Default) method of "2006 IPCC Guidelines".

- ありがとうございました
- ขอบคุณ มาก ครับ/ค่ะ
- Thank you very much

Appendix

- The method of calculating the GHG of AFOLU Sector in Japan
- Issue of AFOLU Sector in Thailand
- Data source is "National Greenhouse Gas Inventory Report of JAPAN (Ministry of the Environment, Japan, Greenhouse Gas Inventory Office of Japan (GIO), CGER, NIES)"

The method of calculating the GHG of AFOLU Sector in Japan

- Land Use Category
  - Stock-Difference Method
  - Use Approach 2 (Total Land-Use Area, Including Changes Between Categories)
- Agriculture
  - Enteric Fermentation (Cattle, Buffalo, Sheep, Goats, Horse and Swine)
  - Manure Management (Cattle, Buffalo, Sheep, Goats, Horses, Swine and Poultry)
  - Rice Cultivation
  - Agricultural Soils (Direct N_2O Emissions, Indirect N_2O Emissions)
  - Field Burning (Grains, Legumes, root crops and sugar cane)

Characteristics of Japanese Land

Total land area	About 37.8 ha
Forestland	About 25.0 ha
Cropland	About 4.01 ha
Grassland	About 0.91 ha
Wetland	About 1.33 ha
Settlements	About 3.70 ha
Other land	About 2.88 ha

Japan's Location and Climate, etc.

Item	Note
Land	Hokkaido, Honshu, Shikoku, Kyushu, and other islands.
Northernmost Southernmost	Latitude about 45 degrees centigrade N Latitude about 20 degrees centigrade N
Climate	Most; temperate, humid climate zone Some southern parts; subtropical climate zone Some northern parts; cool-temperate climate zone
Tokyo	Humid climate zone, Temperature 15.9℃ ,Rainfall 1,466.7mm
Sapporo	Cool-temperate climate zone , Temperature 8.5℃, Rainfall 1,127.6mm
Naha	Subtropical climate zone, Temperature 22.7℃ ,Rainfall 2,036.9 mm

Land Use Transition Matrix for Japan in FY1990 (unit: kha) (Approach 2)

Before Conversion / After Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest land	24,946.8	2.7	0.7	IE	IE	0.1	24,950.3
Cropland	7.0	4,587.6	0.0	0.3	IE	1.5	4,596.4
Grassland	1.0	0.9	924.6	0.2	IE	3.7	930.3
Wetlands	0.3	0.1	0.0	1,319.4	0.0	0.1	1,320.0
Settlements	19.3	21.4	3.2	IE	3,173.2	IE	3,217.0
Other land	4.8	15.3	3.8	IE	IE	2,732.1	2,756.0
Total	24,979.3	4,627.9	932.3	1,320.0	3,173.2	2,737.5	37,770.0

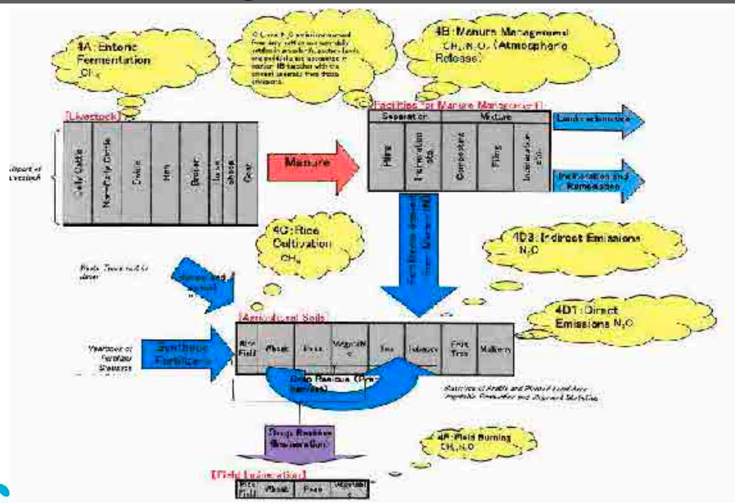
Land Use Transition Matrix for Japan in FY2008 (unit: kha) (Approach 2)

Before Conversion / After Conversion	Forest land	Cropland	Grassland	Wetlands	Settlements	Other land	Total
Forest land	24,968.5	0.5	0.1	IE	IE	0.1	24.969.1
Cropland	0.5	4,005.1	0.0	0.5	IE	0.6	4,006.7
Grassland	0.1	0.8	905.8	0.4	IE	0.7	907.8
Wetlands	0.3	0.2	0.0	1,329.2	0.0	0.3	1,330.0
Settlements	5.1	10.9	1.6	IE	3,679.4	IE	3,697.0
Other land	0.7	8.6	3.8	IE	IE	2,866.2	2,879.3
Total	24,975.2	4,026.1	911.4	1,330.1	3,679.4	2,867.8	37,790.0

The characteristic of the Japan's GHG Inventory (Land Use, Land-use Change and Forestry (LULUCF) Sector)

	Emissions or removals	Note
5.A. Forest land	Net removals 79,934 Gg-CO2 10.4% Increase over FY1990	All Japan's forests are managed forests
5.B. Cropland	Emissions 223 Gg-CO2 91.3% Decrease over FY1990	Rice field, upland fields, orchards and temporarily fallow land
5.C. Grassland	Net removals 744 Gg-CO2 32.1% Increase over FY1990	Perennial pasture Harvesting fodder/ grazing
5.D. Wetlands	Emissions 92.1 Gg-CO2 2.7% Increase over FY1990	No peat extraction Flooded land (almost dam)
5.E. Settlements	Emissions 831 Gg-CO2 82.4% Decrease over FY1990	Trees existing in urban green areas such as urban park, special greenery conservation zones
5.F. Other land	Emissions 388 Gg-CO2 75.6% Decrease over FY1990	"Defense Facility Site", "Cultivation Abandonment Area", "Coast", etc

Relationships among the categories in the agricultural sector



The characteristic of the Japan's GHG Inventory (Agriculture Sector : part1)

- Enteric Fermentation (4.A.)
  - Activities : the number of each type of livestock at 1 February in each year (Livestock Statistics)
  - Emission Factor : Specific to Japan (measured data)
  - CH_4 : 6,945 Gg-CO_2 (0.5% of total GHG emissions and 9.5% decrease from FY 1990)
- Manure Management (4.B.)
  - Activities : Livestock herd or flock size, volume of feeces or urine excreted, nitrogen content volume, etc.
  - Emission Factor : Specific to Japan and Default value
  - CH_4 : 2,328 Gg-CO_2 (0.2% of total GHG emissions and 24.8% decrease from FY 1990)
  - N_2O : 4,768 Gg-CO_2 (0.4% of total GHG emissions and 13.8% decrease from FY 1990)

The characteristic of the Japan's GHG Inventory (Agriculture Sector : part2)

- Rice Cultivation (4.C.)
  - Activities : Intermittently flooded paddy fields (98%), Continuously flooded paddies (2%) and the planted paddy area (Statistics of Cultivated and Planted area), etc.
  - Emission Factor : Specific to Japan (measured data)
  - CH_4 : 5,614 Gg-CO_2 (0.4% of total GHG emissions and 19.3% decrease from FY 1990)
- Direct Soil Emissions (4.D.)
  - Activities : Amount of nitrogen contained in synthetic fertilizer applied in upland farming , Volume of nitrogen volatilized from ammonia and nitrogen oxides from livestock manure and synthetic fertilizers.
  - Emission Factor : Specific to Japan and Default value
  - N_2O : 6,050 Gg-CO_2 (0.5% of total GHG emissions and 22.8% decrease from FY 1990)

Setting method of the emission factor

- Setting from scientific theory value (CO_2 from energy Combustion, etc.)
- Measurement made at the factories (CH_4 and N_2O from chemical industry (Industrial Process), etc.)
- The results of surveys in Japan (CH_4 and N_2O from the agricultural sector and the waste sector, etc.)
- The default value of the IPCC guideline (N_2O from civil aviation, etc.)

Question

- Q; In the "Agriculture Sector" of Japan's GHG Inventory, the emissions from the "Rice Cultivation" category are largest.
- A; No. The "Enteric Fermentation" category and "Manure Management" category are larger than the "Rice Cultivation" category.

Issues of AFOLU Sector in Thailand

- Rice Cultivation Category is very important. This Category may have much information.
- The emissions from Land-Use category may be able to be sufficiently calculated using "Gain-Loss Method" and "Approach 1".
- Additional information may be needed regarding the estimation of emissions from livestock.

Emissions from Land-Use (ASEAN Countries)

Thailand	CO_2 : 60,476.75 (Gg/year) (21.12 % of total GHG inventory)
Malaysia	CO_2 : -61,081.00 (Gg/year) (-80.80 % of total GHG inventory)
Indonesia	CO_2 : 155,625.00 (Gg/year) (31.23 % of total GHG inventory)
Philippine	CO_2 : -2,774.00 (Gg/year) (-2.75 % of total GHG inventory)
Vietnam	CO_2 : 19,380 (Gg/year) (18.70 % of total GHG inventory)

Emissions from Livestock (ASEAN Countries)

Thailand	CH_4: 769.12 (Gg/year), N_2O: 19.19 (Gg/year) (5.6% and 2.1% of total GHG inventory)
Malaysia	CH_4 : 75.00 (Gg/year) (2.1 % of total GHG inventory)
Indonesia	CH_4 : 947.21 (Gg/year) (3.99 % of total GHG inventory)
Philippine	CH_4 : 333.47 (Gg/year) (6.95 % of total GHG inventory)
Vietnam	CH_4 : 465.60 (Gg/year) (9.42 % of total GHG inventory)

Rice Cultivation (ASEAN Countries)

Thailand	CH_4 : 2,110.53 (Gg/year) (15.5 % of total GHG inventory)
Malaysia	CH_4 : 252.00 (Gg/year) (7.0 % of total GHG inventory)
Indonesia	CH_4 : 2,280.90 (Gg/year) (9.6 % of total GHG inventory)
Philippine	CH_4 : 636.40 (Gg/year) (13.2 % of total GHG inventory)
Vietnam	CH_4 : 1559.70 (Gg/year) (31.5 % of total GHG inventory)

INV06: Overview of Waste Sector
(and Outline of Japan's GHG Inventory Preparation Process)

28 September, 2010

GHG Inventory
Fumihiko KUWAHARA

Contents of Training Program

- 1. Outline of Waste Sector
- 2. Solid Waste Disposal
- 3. Biological Treatment of Solid Waste
- 4. Incineration and Open Burning of Waste
- 5. Wastewater Treatment and Discharge
- 6. Outline of Japan's GHG Inventory Preparation Process

1. Outline of Waste Sector

- Waste Sector has 4 categories.
  - Solid Waste Disposal
  - Biological Treatment of Solid Waste
  - Incineration and Open Burning of Waste
  - Wastewater Treatment and Discharge
- Typically, CH4 emissions from Solid Waste Disposal Sites (SWDS) are the largest source in the Waste Sector.
- CH4 emissions from wastewater treatment and discharge may also be important.

Data Collection

- You should collect and use the country-specific data, because there are various local conditions, uncertainties for default data are large.
- Default waste categories: Municipal Solid Waste (MSW), Sludge, Industrial Waste and Other Waste (e.g. Clinical Waste, Hazardous Waste, Agricultural Waste)

Major Improvements of 2006 IPCC Guidelines

- Improved accuracy: Updated methods and improved default values
  - A simple first order decay (FOD) method for landfills
- More complete:
  - Guidance is given on more sources
    - Biological treatment of solid waste
    - Open burning of waste (important in developing countries)
  - Inclusion of methods to estimate N2O emissions
    - Discharge of wastewater into waterways
    - Advanced wastewater treatment plants

Waste Generation, Composition and Management Data

- Solid Waste Generation : Common Basic Data
- Statistics on Waste Generation and Treatment have been improved substantially in many countries during the last decade.
- However, Very few countries have data on historical waste disposal going back several decades. (need for FOD method)

Solid Waste Source and Management

- Solid Waste is generated from Households, Offices, Shops, Markets, Restaurants, Public Institutions, Industrial Installations, Water Works and Sewage Facilities, Construction and Demolition Site, and Agricultural Activities.
- Solid Waste Management Practices include: Collection, Recycling, Solid Waste Disposal on Land, Biological and Other Treatments as well as Incineration and Open Burning of Waste.

Question (about Waste Data)

- Q: What do you think about data and information of Waste Sector generally?
- A: Country-specific data are important, because there are various local conditions (e.g. economic situation, industrial structure, waste management regulations and life style, etc.).
- A: Historical waste data are important, because there is considerable time lag in emissions after disposal.

2. Solid Waste Disposal

- Significant source of CH4
- Considerable time lag in emissions after disposal – taken into account in the "First Order Decay" (FOD) Model (revised from GPG2000; spreadsheet; can be use for All Tiers)
  - Default parameters provided (updated values – decay rates by climate zone)
  - Default regional activity data (guidance how to estimate historical disposal)
  - CH4 recovery – guidance improved

GHG Emissions from "Solid Waste Disposal on Land" in Japan

- GHG Emissions : 3,591 Gg-CO2 eq./year (0.3 % of Japan's total GHG emissions)
- CH4 emissions decrease is the result that the amount of the waste incineration has increased to reduce waste volume.

IPCC FOD Model (CH4 Emission)

- The degradable organic component in waste decays slowly throughout a few decades.
- CH4 Emissions

$$\text{CH4 Emissions} = \left[\sum_{x} \text{CH4 generated}_{x,T} - R_T\right] \times (1 - OX_T)$$

  - CH4 Emissions = CH4 emitted in year T, Gg
  - T = inventory year
  - x = waste category or type/material
  - R_T = recovered CH4 in year T, Gg
  - OX_T = oxidation factor in year T, (fraction)

IPCC FOD Model (CH4 generated from decomposable DDOCm)

- CH4 Generation
  - CH4 generated_T = DDOCm decomp_T x F x 16/12
    - DDOC: Decomposable Degradable Organic Carbon
    - CH4 generated_T = amount of CH4 generated from decomposable material
    - DDOCm decomp_T = DDOCm decomposed in the SWDS in year T
    - F = fraction of CH4, by volume, in general landfill gas (fraction)
    - 16/12 = molecular weight ration CH4/C (ratio)

IPCC FOD Model (First Order Decay Basic)

- DDOC: Decomposable Degradable Organic Carbon
  - $DDOCma_T = DDOCmd_T + (DDOCma_{T-1} \times exp(-k))$
  - $DDOCm\ decomp_T = DDOCma_{T-1} \times (1 - exp(-k))$
    - $DDOCma_T$ = DDOCm accumulated in the Solid Waste Disposal Sites (SWDS) at the end of year T
    - $DDOCma_{T-1}$ = DDOCm accumulated in the SWDS at the end of year T-1
    - $DDOCmd_T$ = DDOCm deposited in the SWDS in year T
    - $DDOCm\ decomp_T$ = DDOCm decomposed in the SWDS in year T
    - T: inventory year, k: reaction constant

For example: IPCC FOD Model (Trial Calculation of Japan's Case)

- Calculation Conditions
  - It is the demonstration of FOD Model which is offered by IPCC (IPCC_Waste_Model.xls).
  - When you chose the area, this worksheet calculates automatically.
  - The amounts of Municipal Solid Waste and Industrial Waste are used. The waste is not classified more in detail. Therefore, it is a little different from the results of "National Greenhouse Gas Inventory Report of Japan".
  - The results are calculated by the default value of East Asia.

For example: IPCC FOD Model (Trial Calculation of Japan's Case , MSW, part1)

		National values
DOC	DOC	0.14
DOCf	DOCf	0.500
Methane generation rate constant	k	0.090
Half-life time ($t_{1/2}$, years)	h = ln(2)/k	7.7
exp1	exp(-k)	0.91
Process start in deposition year. Month M	M	13.00
exp2	exp(-k*((13-M)/12))	1.00
Fraction to CH4	F	0.500

Year	Amount deposited	MCF	DOC	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	DOC	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1 - exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1978	10,915	0.71	0.14	540	540	0	540	0	0
1979	11,194	0.71	0.14	552	552	0	1,046	46	31
1980	10,843	0.71	0.14	535	535	0	1,491	90	60
1981	9,400	0.71	0.14	468	468	0	1,831	128	86
1982	10,003	0.71	0.14	494	494	0	2,167	158	105
1983	9,220	0.71	0.14	455	455	0	2,436	187	124
1984	8,908	0.71	0.14	440	440	0	2,666	210	140
1985	8,820	0.71	0.14	436	436	0	2,872	229	153
1986	8,811	0.71	0.14	435	435	0	3,059	247	165
1987	9,067	0.71	0.14	447	447	0	3,244	263	176
1988	9,293	0.71	0.14	459	459	0	3,423	279	186
1989	9,354	0.71	0.14	462	462	0	3,590	295	196
1990	9,245	0.71	0.14	456	456	0	3,737	309	206
1991	9,008	0.71	0.14	445	445	0	3,860	322	214
1992	8,413	0.71	0.14	415	415	0	3,943	332	221

For example: IPCC FOD Model (Trial Calculation of Japan's Case, MSW, part2)

		National values
DOC	DOC	0.14
DOCf	DOCf	0.500
Methane generation rate constant	k	0.090
Half-life time ($t_{1/2}$, years)	h = ln(2)/k	7.7
exp1	exp(-k)	[illegible]
Process start in deposition year. Month M	M	13.00
exp2	exp(-k*((13-M)/12))	[illegible]
Fraction to CH4	F	0.500

Year	Amount deposited	MCF	DOC	Decomposable DOC (DDOCm) deposited	DDOCm not reacted. Deposition year	DDOCm decomposed. Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	DOC	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1 - exp2)	H = B + ($H_{last\ year}$ * exp1)	E = C + $H_{last\ year}$ * (1 - exp1)	Q = E * 16/12 * F
	Gg	fraction	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1993	[illegible]	0.71	0.14	406	406	0	4,010	339	226
1994	[illegible]	0.71	0.14	394	394	0	4,046	345	230
1995	7,401	0.71	0.14	369	369	0	4,068	348	232
1996	7,201	0.71	0.14	365	365	0	4,074	350	233
1997	6,601	0.71	0.14	326	326	0	4,050	351	234
1998	6,241	0.71	0.14	308	308	0	4,008	349	232
1999	5,97[illegible]	0.71	0.14	295	295	0	3,959	345	230
2000	[illegible]	0.71	0.14	285	285	0	3,904	341	227
2001	5,47[illegible]	0.71	0.14	270	270	0	3,831	336	224
2002	4,967	0.71	0.14	245	245	0	3,743	330	220
2003	[illegible]	0.71	0.14	229	229	0	3,658	321	215
2004	4,451	0.71	0.14	220	220	0	3,564	315	210
2005	4,032	0.71	0.14	199	199	0	3,450	307	204
2006	[illegible]	0.71	0.14	185	185	0	3,343	297	198
2007	[illegible]	0.71	0.14	172	172	0	3,220	291	194

For example: IPCC FOD Model (Trial Calculation of Japan's Case, Industrial Waste, part1)

		National values
DOC	DOC	0.150
DOCf	DOCf	0.500
Methane generation rate constant	k	0.090
Half-life time ($t_{1/2}$, years)	h = ln(2)/k	7.7
exp1	exp(-k)	0.91
Process start in deposition year. Month M	M	13.00
exp2	exp(-k*((13-M)/12))	1.00
Fraction to CH4	F	0.500

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted Deposition year	DDOCm decomposed Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + (H lastyear * exp1)	E = C + (H last year * (1 - exp1))	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1900	6,800	0.72	365	365	0	365	0	0
1981	0	0.72	0	0	0	333	31	21
1902	0	0.72	0	0	0	305	29	19
1983	0	0.72	0	0	0	278	26	17
1984	0	0.72	0	0	0	254	24	16
1985	9,100	0.72	488	488	0	720	22	15
1986	0	0.72	0	0	0	658	62	41
1987	0	0.72	0	0	0	602	57	38
1988	0	0.72	0	0	0	550	52	35
1989	0	0.72	0	0	0	503	47	32
1990	8,900	0.72	477	477	0	937	43	29
1991	9,100	0.72	488	488	0	1,344	81	54
1992	8,900	0.72	477	477	0	1,706	116	77

For example: IPCC FOD Model (Trial Calculation of Japan's Case, Industrial Waste, part2)

		National values
DOC	DOC	0.150
DOCf	DOCf	0.500
Methane generation rate constant	k	0.090
Half-life time ($t_{1/2}$, years)	h = ln(2)/k	7.7
exp1	exp(-k)	0.91
Process start in deposition year. Month M	M	13.00
exp2	exp(-k*((13-M)/12))	1.00
Fraction to CH4	F	0.500

Year	Amount deposited	MCF	Decomposable DOC (DDOCm) deposited	DDOCm not reacted Deposition year	DDOCm decomposed Deposition year	DDOCm accumulated in SWDS end of year	DDOCm decomposed	CH_4 generated
	W	MCF	D = W * DOC * DOCf * MCF	B = D * exp2	C = D * (1-exp2)	H = B + (H lastyear * exp1)	E = C + (H last year * (1 - exp1))	Q = E * 16/12 * F
	Gg	fraction	Gg	Gg	Gg	Gg	Gg	Gg
1993	8,400	0.72	450	450	0	2,009	147	98
1994	8,000	0.72	429	429	0	2,265	173	115
1995	6,900	0.72	370	370	0	2,440	195	130
1996	6,800	0.72	365	365	0	2,595	210	140
1997	6,700	0.72	359	359	0	2,731	223	149
1998	5,800	0.72	311	311	0	2,807	235	157
1999	5,000	0.72	268	268	0	2,833	242	161
2000	4,500	0.72	241	241	0	2,831	244	163
2001	4,200	0.72	225	225	0	2,812	244	162
2002	4,000	0.72	215	215	0	2,785	242	161
2003	3,000	0.72	161	161	0	2,706	240	160
2004	2,600	0.72	139	139	0	2,613	233	155
2005	2,400	0.72	129	129	0	2,516	225	150
2006	2,200	0.72	118	118	0	2,418	217	144

Japan's Case Study 1 (Solid Waste Disposal)

- Estimation Method
  $$E = \left\{ \sum \left(EF_{i,j} \times A_{i,j} \right) - R \right\} \times (1 - OX)$$
- EF: CH4 emissions from biodegradable waste
- Activity Data: the amount of waste biodegraded within the reporting year
- R: Recovered CH4 in an inventory year
- Ox: Oxidation factor of CH4 related to soil cover

Japan's Case Study 1 (Solid Waste Disposal, Emission Factor)

- Emission Factor = (Carbon Content) x (Gas Conversion Rate) x (CH4 Correction Factor) x (percentages of CH4 in landfill gas) x 1000 / 12 x 16
  - Carbon contents of kitchen garbage, waste paper and waste wood were calculated by taking averages of carbon contents of MSW provided by Tokyo, Yokohama, Kawasaki, Kobe, and Fukuoka.
  - Carbon contents of waste natural fiber textiles were substituted by the ones of natural fibers in textile products.
  - Carbon contents of digested sewage sludge was determined by expert judgment using the survey results.
  - The upper limit of the carbon content sewage sludge indicated in the GPG (2000) was applied to the carbon content of "other sewage sludge"

Carbon content of waste disposed of in managed landfill sites

		1990	1995	2000	2005	2006	2007	2008
Kitchen garbage	%	43.4	43.4	43.4	43.4	43.4	43.4	43.4
Waste paper	%	40.9	40.9	40.9	40.9	40.9	40.9	40.9
Waste textiles (natural fiber)	%	45.2	45.2	45.2	45.2	45.2	45.2	45.2
Waste wood	%	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Digested sewage sludge	%	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Other sewage sludge	%	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Human waste treatment, Septic tank	%	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Waterworks sludge	%	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Organic sludge from manufacturing	%	45.0	45.0	45.0	45.0	45.0	45.0	45.0
Livestock Waste	%	40.0	40.0	40.0	40.0	40.0	40.0	40.0

Japan's Case Study 1 (Solid Waste Disposal, Emission Factor)

- Other Parameter
  - "Gas conversion Rate" for the biodegradable waste was set at 50% based on survey report.
  - "CH4 correction factor" is Default Value. (1.0 for anaerobic landfill sites, 0.5 for semi-aerobic landfill site ← 2006 IPCC Guideline)
  - "Proportions of CH4 in generate gas" is Default Value (50%) given in the Revised 1996 IPCC Guidelines.

Japan's Case Study 1 (Solid Waste Disposal, Activity Data)

- Out of the amount of waste landfilled without incineration (dry basis), the amount of waste degraded within the reporting year was calculated by multiplying the amount of waste remaining in landfills at the end of the previous reporting year by the decomposition rate for waste landfilled.
- The Equation is as follow;

Japan's Case Study 1 (Solid Waste Disposal, Activity Data)

- Activity Data: The amounts of waste i landfilled in year T
  = (Amount of biodegraded waste i landfilled in year T)
  x (Percentages of landfill sites of each site type)
  x (1- percentage of waste content in waste i)

Annual Amount of Biodegradable Waste Disposed of in Landfills

Item	Unit	1990	1995	2000	2005	2006	2007	2008
Kitchen garbage	kt / year (dry)	501	483	297	110	98	50	52
Waste paper	kt / year (dry)	1,179	868	611	290	247	82	71
Waste textiles (natural fiber)	kt / year (dry)	59	48	31	20	13	7	5
Waste wood	kt / year (dry)	652	476	221	152	142	76	39
Digested sewge sludge	kt / year (dry)	59	50	31	11	8	5	4
Other sewage sludge	kt / year (dry)	219	185	114	42	29	20	17
Human waste treatment, Septic tank	kt / year (dry)	78	51	46	47	29	21	21
Waterworks sludge	kt / year (dry)	199	166	146	66	62	67	67
Organic sludge from manufacturing	kt / year (dry)	341	155	69	48	39	34	35
Livestock waste	kt / year (dry)	12	12	11	11	11	11	12
Total	kt / year (dry)	3,299	2,494	1,577	796	677	373	324

- The above table shows the annual amount of biodegradable waste disposed of in landfills (dry basis) in Japan.
- Each data are estimated using the various statistics as shown in below.

Sources of Annual Amount of Biodegradable Waste Disposed of in Landfills (Part1)

- Kitchen garbage, waste paper, waste wood
  - The amount of directly landfilled kitchen garbage, waste paper, and waste wood were extracted from "the Report of the Research on the State of Wide-range Movement and Cyclical Use of Waste" (Volume on Cyclical Use) (Waste Management and Recycling Department of the Ministry of the Environment; hereafter, "Cyclical Use of Waste Report")
  - Landfilled amounts of both the MSW and the industrial waste were determined back to 1980 (some years were interpolated) and the 1980 value was used for the years prior to 1980.

Sources of Annual Amount of Biodegradable Waste Disposed of in Landfills (Part2)

- Waste Natural Fiber Textiles
  - The amount of waste natural fiber textiles directly landfilled was estimated from the "Cyclical Use of Waste Report" and so on. For MSW, the percentages of waste natural fiber textiles were annually extracted from the "Annual Textile Statistics Report".
  - The landfilled amount in the past year was estimated using the same method used for kitchen garbage, waste paper, waste wood.
- Sewage Sludge
  - The total amount of sewage sludge landfilled was provided by the annual editions of "Sewage Statistics" (Japan Sewage Works Association).
  - The amount of landfilled sewage sludge in the past as far as 1985 were obtained (some years are interpolated), and the 1985 value was used for the years prior to 1985.

Sources of Annual Amount of Biodegradable Waste Disposed of in Landfills (Part3)

- Human waste treatment, septic tank sludge
  - Landfilled amount of human waste treatment and septic tank sludge were determined from "Cyclical Use of Waste Report", etc.
  - Data prior to 1998 are estimated by using other statistics.
- Waterworks Sludge
  - Amount of water purification sludge were extracted from "annual editions of Waterworks Statistics" (Japan Water Works Association).
  - Landfilled amounts in the past were determined back to 1980 and the 1980 amount was used for the year prior to 1980.

Sources of Annual Amount of Biodegradable Waste Disposed of in Landfills (Part4)

- Organic Sludge from Manufacturing Industries
  - Landfilled amount of Organic Sludge from manufacturing Industries were determined by using "the final disposal amount (dry basis) of organic sludge in Results of a Study on Industrial Waste from Paper and Pulp Plants (Japan Paper Association)" and "Report on Results of Trend and Industry-Specific Studies on Industrial Waste and Recyclable Waste (Clean Japan Center)", etc.
  - Landfilled amounts in the past were determined back to 1989 and the 1989 amount was used for the year prior to 1989.
- Livestock Waste Treatment
  - The amount of livestock waste landfilled was provided by "the survey conducted by the Ministry of the Environment in 2009".
  - The data were provided as far as 1980, and the data for 1980 was also used for the years prior to 1980.

Percentage of water content in waste disposed of in controlled landfill sites

Table 8-5 Percentage of water content in waste disposed of in controlled landfill sites

Category		Water content (%)	Source
Kitchen garbage, animal and plant residues		75 (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*
		70 (final disposal after treatment)	
Waste paper		20 (MSW) 15 (ISW)	Expert judgment
Waste natural fiber textiles		20 (MSW) 15 (ISW)	Expert judgment
Waste wood		45	Expert judgment
Sewage sludge	Digested sewage sludge	Specific to each disposal site	Average moisture content of "delivered or final disposal sludge" in *Sewage Statistics (Admin. Ed.)*
	Other sewage sludge		
Sludge from human waste treatment and septic tanks		85 (direct final disposal)	Moisture content standard of landfill standard (sludge) specified by enforcement ordinance of Wastes Disposal and Public Cleansing Law
		70 (final disposal after treatment)	Determined by specialists
Waterworks Sludge		- [illegible]	—
Livestock waste		83.1 (direct final disposal)	Organic percentage in "*Controlling the Generation of Greenhouse Gases in the Livestock Industry*"
		70 (final disposal after treatment)	Expert judgment
Organic sludge from manufacturing industries		23 (food manufacturing) 43 (chemical industries) - (paper industries) *	Reference of Clean Japan Center Survey

*The water content of waterworks sludge and organic sludge from paper industries are not included in this table because activity data on a dry basis were provided by the data sources.

Other Parameters

Table 8-6 Landfill percentage of municipal solid waste disposal sites by site structure

Item	Unit	1977	1980	1985	1990	1995	2000	2005	2008
Anaerobic landfill percentage	%	100.0	94.0	84.1	74.2	64.2	54.4	43.5	40.5
Semi-aerobic landfill percentage	%	0.0	6.0	15.9	25.8	35.8	45.6	56.5	59.5

Table 8-8 Amount of CH_4 recovered at landfill sites in Japan (Gg-CH_4)

Item	Unit	1990	1995	2000	2005	2006	2007	2008
Amount of gaseous use	km^3N	1,985	2,375	2,372	140	1,309	1,157	1,161
CH_4 ratio	%	53.3	42.2	40.0	48.5	42.1	37.4	37.1
Amount of CH_4 use	km^3N	1,059	1,003	949	68	551	433	431
CH_4 unit conversion	Gg CH_4	0.76	0.72	0.68	0.05	0.39	0.31	0.31

Amount of biodegraded waste decomposed in each year (Activity Data)

- Decomposition half-life (kitchen waste: 3 years, waste paper & natural fiber textiles: 7 years, waste wood: 36 years, sludge: 3.7 years)
- Delay time = 6 months
- The results of Activity Data are as follow table.

Table 8-7 Amount of biodegraded waste decomposed in each year (Activity data)

Item	Unit	1990	1995	2000	2005	2006	2007	2008
Kitchen garbage	kt / year (dry)	517	51[illegible]	444	304	264	230	193
Waste paper	kt / year (dry)	1,216	1,1[illegible]	995	803	754	706	648
Waste textiles (natural fiber)	kt / year (dry)	73	65	55	45	43	40	37
Waste wood	kt / year (dry)	344	377	373	357	353	349	343
Digested sewage sludge	kt / year (dry)	63	58	47	31	27	21	21
Other sewage sludge	kt / year (dry)	234	219	176	114	102	90	78
Human waste treatment, Septic	kt / year (dry)	111	84	61	51	51	47	43
Waterworks sludge	kt / year (dry)	192	185	157	120	111	103	97
Organic sludge from	kt / year (dry)	359	288	181	118	106	95	84
Livestock waste	kt / year (dry)	12	12	12	11	11	11	11
Total	kt / year (dry)	3,151	2,976	2,504	1,954	1,822	1,694	1,554

Conclusion (Japan's Case: Solid Waste Disposal)

- There are not complete data in Japan since the past year.
- Activities are estimated by using many statistics in Japan.
- Many statistics data are determined back to 1980 and the 1980 value is used for the year prior to 1980.
- Since the past data contribute lower, the accuracy of past data need not be too much in the case of the calculation of FOD Model.

Question (about Solid Waste Disposal)

- Q: What is the "First Order Decay (FOD)" method?
- A: This method assumes that the degradable organic component (degradable organic carbon) in waste decays slowly throughout a few decades, during which CH_4 and CO_2 are formed.

4. Incineration and Open Burning of Waste

- The mainly basic equation: Emissions = Activity Data x Emission Factor (can be used for All Tiers)
- CO_2 : calculate as the combustion of fossil carbon
- CH_4 : a result of incomplete combustion
- N_2O : combustion processes at relatively low combustion temperatures between 500 and 950 degrees C

GHG Emissions from "Incineration of Waste" in Japan

- GHG Emissions : 13,398 Gg-CO_2 eq./year (1.3 % of Japan's total GHG emissions)
- In Japan, Waste has been reduced in volume primarily by incineration.
- Japan has a lot of "Incinerators" of Waste.

Tier1 method (Incineration and Open Burning of Waste; CO2)

- CO2 Emissions = SW_i x dm_i x CF_i x FCF_i x OF_i x 44/12
  - SW_i : total amount of solid waste of type i incinerated or open-burned, Gg/year
  - dm_i : dry matter content in the waste incinerated or open burned, (fraction)
  - CF_i : fraction of carbon in the dry matter (total carbon content), (fraction)
  - FCF_i : fraction of fossil carbon in the total carbon, (fraction)
  - OF_i : oxidation factor, (fraction)
  - 44/12 : conversion factor from C to CO2
  - i : category or type of waste

3. Biological Treatment of Solid Waste

- The mainly basic equation (can be used for All Tiers)
- CH4 Emissions = Mass x EF – R
- N2O Emissions = Mass x EF
  - Mass : mass of organic waste treated by biological treatment
  - EF: emission factor for treatment
  - R: total amount of CH4 recovered

Tier1 method (Incineration and Open Burning of Waste; CH4 and N2O)

- CH4 and N2O Emissions = IW_i x EF_i
  - IW_i : amount of incinerated/open-burned waste of type i, Gg/year
  - EF_i : emission factor for waste of type i
  - i : category or type of waste incinerated/open-burned (MSW: municipal solid waste, ISW: industrial solid waste, HW: hazardous waste, CW: clinical waste, SS: sewage sludge, others)

Question (about Incineration and Open Burning of Waste)

- Q: What will you consider when you calculate the GHG emissions from "Incineration and Open Burning of Waste"?
- A: Emissions from waste incineration without energy recovery are reported in the "Waste Sector", while emissions from incineration with energy recovery are reported in the "Energy Sector".
- Additionally, You should make clear distinction between fossil and biogenic CO2 emissions.
- "Open burning" is similar to the incineration.
- Emissions from agricultural residue burning are considered in the "AFOLU Sector".

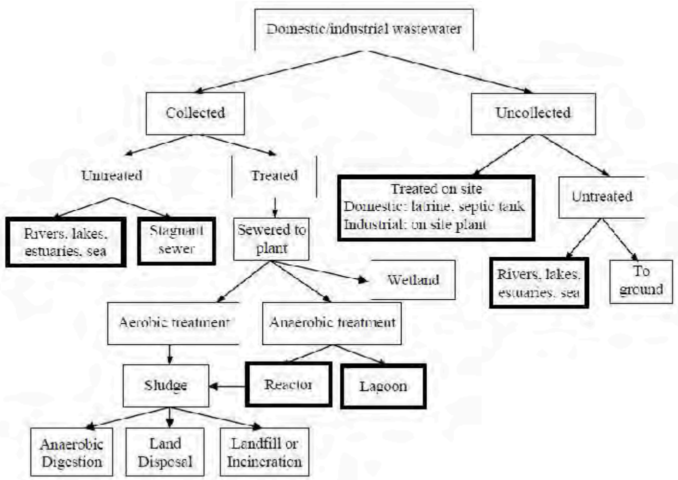
5. Wastewater Treatment and Discharge

- A source of CH4 (treated or disposed anaerobically)
- A source of N2O (associated with the degradation of nitrogen components in the wastewater, e.g. urea, nitrate and protein)
- CO2 are not considered in the IPCC GL (biogenic origin)

GHG Emissions from "Wastewater Treatment and Discharge" in Japan

- GHG Emissions : 2,501 Gg-CO2 eq./year (0.2 % of Japan's total GHG emissions)
- Emission factor takes into account emissions from wastewater and sludge treatment process.

Wastewater Treatment Systems and discharge pathways



CH4 and N2O Emission Potentials

- "Collected" and "Untreated"

Types of Treatment and Disposal	CH4 and N2O Emission Potentials
River discharge	Stagnant, oxygen-deficient rivers and lakes may allow for anaerobic decomposition to produce CH4. Rivers, lakes and estuaries are likely sources of N2O
Sewers (closed and under ground)	Not a source of CH4/N2O
Sewers (open)	Stagnant, overloaded open collection sewers or ditches/canals are likely significant sources of CH4

CH4 and N2O Emission Potentials

- "Collected" and "Treated" and "Aerobic Treatment"

Types of Treatment and Disposal	CH4 and N2O Emission Potentials
Centralized aerobic wastewater treatment plants	May produce limited CH4 from anaerobic pockets. Poorly designed or managed aerobic treatment systems produce CH4. Advanced plants with nutrient removal (nitrification and denitrification) are small but distinct sources of N2O
Sludge anaerobic treatment in centralized aerobic wastewater treatment plant	Sludge may be a significant source of CH4 if emitted CH4 is not recovered and flared.
Aerobic shallow ponds	Unlikely source of CH4/N2O Poorly designed or managed aerobic systems produce CH4

CH4 and N2O Emission Potentials

- "Collected" and "Treated" and "Anaerobic Treatment"

Types of Treatment and Disposal	CH4 and N2O Emission Potentials
Anaerobic lagoons	Likely source of CH4 Not a source of N2O
Anaerobic reactors	May be a significant source of CH4 if emitted CH4 is not recovered and flared.

CH4 and N2O Emission Potentials

- "Uncollected"

Types of Treatment and Disposal	CH4 and N2O Emission Potentials
Septic tanks	Frequent solids removals reduces CH4 production.
Open pits/Latrines	Pits/latrines are likely to produce CH4 when temperature and retention time are favourable.
River discharge	Stagnant, oxygen-deficient rivers and lakes may allow for anaerobic decomposition to produce CH4. Rivers, lakes and estuaries are likely sources of N2O

Tier 1 method (Wastewater Treatment, Step 1)

- Default values for Emission Factors and Activity Parameters (B_0, MCF, etc.)
- Step 1 : Estimate total organically degradable carbon in wastewater (TOW)
- TOW = P x BOD x 0.001 x I x 365
  - TOW : total organic in wastewater in inventory year, kg BOD/yr
  - P : country population in inventory year, (person)
  - BOD : country-specific per capita BOD in inventory year, g/person/day
  - 0.001 : conversion from grams BOD to kg BOD
  - I : correction factor for additional industrial BOD discharged into sewers

Tier 1 method (Wastewater Treatment, Step 2)

- Step 2 : Select the pathway and system according to country activity data
- Obtain the emission factor for each domestic wastewater treatment/discharge pathway or system
- $EF_j = B_0 \times MCF_j$
  - EF_j : emission factor, kg CH4/kg BOD
  - j : each treatment/discharge pathway or system
  - B_0 : maximum CH4 producing capacity kg CH4/kg BOD
  - MCF_j : methane correction factor (fraction)

Tier 1 method (Wastewater Treatment, Step 3)

- Step 3 : Estimate emissions, adjust for possible sludge removal and/or CH4 recovery and sum the results for each pathway/system.
- $CH4 = (U_i \times T_{i,j} \times EF_j) \times (TOW - S) - R$
  - S : organic component
  - U_i : fraction of population in income group i in inventory year
  - $T_{i,j}$: degree of utilisation of treatment/discharge pathway or system, j, for each income group fraction i inventory year
  - i : income group : rural, urban high income and urban low income
  - j : each treatment/discharge pathway or system
  - EF_j : emission factor, kg CH4/ kg BOD
  - R : amount of CH4 recovered in inventory year, kg CH4/yr

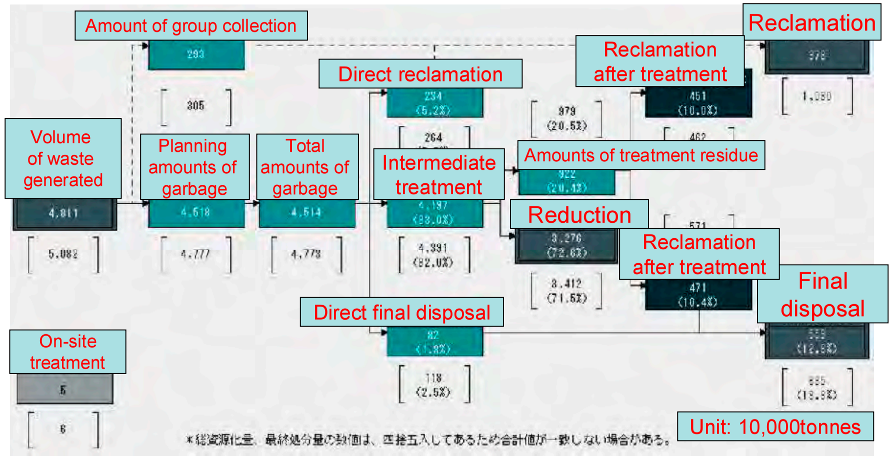
Question (about Wastewater Treatment)

- Q: Which categories are the GHG emissions from "Sludge" reported in?
- A: The emissions from “Sludge Treatment” at wastewater treatment facilities are reported in “Wastewater Treatment and Discharge” category.
- A: The emissions from “Land disposal” of Sludge are reported in “Solid Waste Disposal” category.
- A: The emissions from “Composting” of Sludge are reported in “Biological Treatment of Solid Waste”. Category.
- A: The emissions from “Incineration” of Sludge are reported in “Incineration and Open Burning of Waste” category.
- A: Sludge that is applied on agricultural land is considered in “Agriculture, Forestry and Other Land Use (AFOLU)” sector.

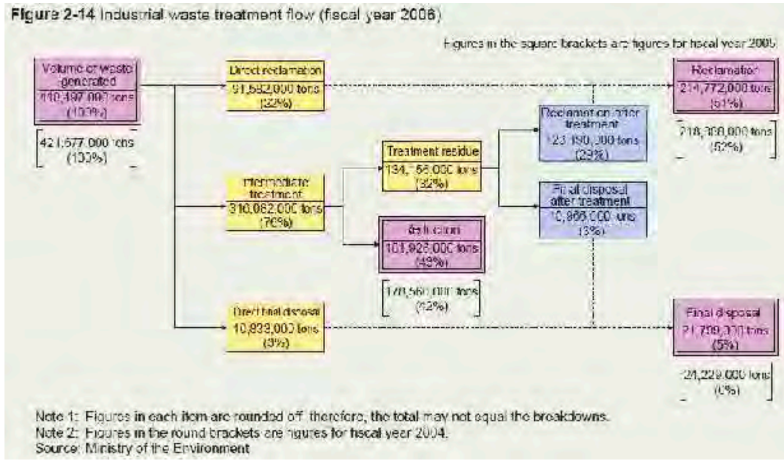
Outline of the GHG from Waste Sector in Japan

- In FY 2008, emissions from the waste sector amounted to 20,052 Gg-CO2 eq. and represented 1.6% of Japan’s total GHG emissions.
- Japan’s Waste : municipal waste, industrial waste and recyclables and valuables that are re-used within a company
- In Japan, the tendency of annual waste generation has remained roughly flat since FY 1990.
- The final disposal amount in Japan has been decreasing year by year.
- Data source is “National Greenhouse Gas Inventory Report of JAPAN (Ministry of the Environment, Japan, Greenhouse Gas Inventory Office of Japan (GIO), CGER, NIES)”

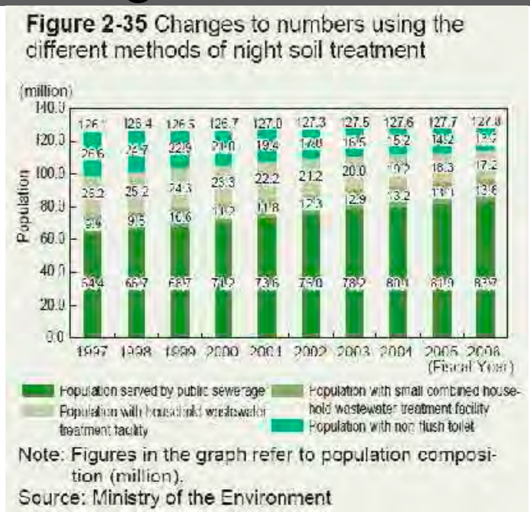
Japan's Waste Flow (Municipal Waste (excluding Industrial Waste); 2008)



Japan's Waste Flow (Industrial Waste; 2006)



Changes to numbers using the different methods of night soil treatment in Japan



The characteristic of the Japan's GHG Inventory (Waste Sector)

	GHG Emissions	Note
6.A. Solid Waste Disposal on Land	3,591 Gg-CO2 eq. 0.3 % (FY 2008)	CH4 emissions decrease is the result that the amount of the waste incineration has increased to reduce waste volume.
6.B. Wastewater Handling	2,501 Gg-CO2 eq. 0.2 % (FY 2008)	Emission factor takes into account emissions from wastewater and sludge treatment process
6.C. Waste Incineration	13,398 Gg-CO2 eq. 1.3 % (FY 2008)	Waste has been reduced in volume primarily by incineration
6.D. Others	562 Gg-CO2 eq. 0.04 % (FY 2008)	Decomposition of petroleum-derived surfactants, etc

Question (about Japan's Waste Sector)

- Q; Why have Japan's GHG emissions from Waste Sector decreased?.
- A: CH4 Emissions decrease is the result of decrease in the amount of biodegradable waste landfilled due to the increase the practice of waste incineration in order to reduce waste volume in Japan.
- In Japan, annual waste generation is amounted to around 600 Mt and it has remained roughly flat since FY 1990.

Issues of Waste Sector in Thailand

- About GHG emissions from the waste sector, Thailand and ASEAN Countries are compared.
- I feel that there are few emissions from the waste sector in comparison with Japan and each Southeast Asia country.
- Underestimate ? or Different treatment method ? or ……? (1994 National Communication)
- Waste Incineration (CO2, CH4, N2O) ?

CH_4 from Landfills (ASEAN Countries)

Thailand	Municipalities : 4.505 (CH4 Gg) Bangkok : 3.958 (CH4 Gg) (not include "Trench dump" and "Open dump")
Malaysia	1,043 (CH4 Gg)
Indonesia	402 (CH4 Gg) * Waste/Landfill (The detail is unclear.)
Philippine	202.53 (CH4 Gg) * Solid Wastes (The detail is unclear.)
Vietnam	66.298 (CH4 Gg) * Solid Wastes (The detail is unclear.)

CH_4 from Wastewater Treatment (ASEAN Countries)

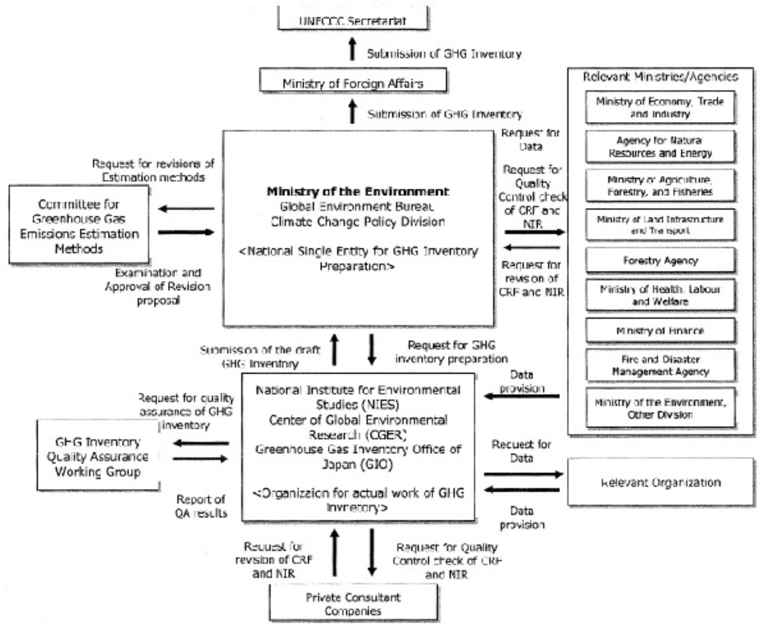
Thailand	Domestic wastewater : 1.77 (CH4 Gg) Industrial wastewater : 13.88 (CH4 Gg)
Malaysia	Domestic/Commercial wastewater :3.5 (CH4 Gg) Industrial wastewater : 220 (CH4 Gg)
Indonesia	402 (CH4 Gg) * Waste/Landfill (The detail is unclear.)
Philippine	Domestic/Commercial wastewater :46.02 (CH4 Gg) Industrial wastewater : 43.83 (CH4 Gg)
Vietnam	Domestic/Commercial wastewater :1.027 (CH4 Gg) Industrial wastewater : 0.79 (CH4 Gg)

5. Outline of Japan's GHG Inventory Preparation Process

- Roles and responsibilities of each entity involved in the inventory preparation process
- Brief Description of the Inventory Preparation Process
- Others

Following are the "agencies" involved in the inventory compilation process.

- Ministry of the Environment (Climate Change Policy Division, Global Environment Bureau)
- Greenhouse Gas Inventory Office of Japan (GIO), Center for Global Environmental Research, National Institute for Environmental Studies
- Relevant Ministries/Agencies
- Relevant Organization
- Committee for the Greenhouse Gas Emissions Estimation Methods
- GHG Inventory Quality Assurance Working Group (Expert Peer Review)
- Private Consulting Companies



Roles and responsibilities of each entity (part1)

- Ministry of the Environment (MOE)
  - The single national agency responsible for preparing Japan's inventory
  - It is responsible for editing and submitting the inventory
- Greenhouse Gas Inventory Office of Japan (GIO)
  - Performs the actual work of inventory compilation. Responsible for inventory calculation, editing, and the archiving and management of all data

Roles and responsibilities of each entity (part2)

- Relevant Ministries/Agencies
  - 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 MOE and GIO
  - Confirmation and Verification of the Inventory (CRF, NIR, Spreadsheets, and other information)
  - And so on.

Roles and responsibilities of each entity (part3)

- Relevant Organization
  - For example: "Federation of Electric Power Companies", "Japan Coal Energy Center", "Japan Cement Association", etc.
  - Preparation of Activity data, Emission Factor data, other data, and submission of the data by the submission deadline
  - QC of the data provided to MOE and GIO

Roles and responsibilities of each entity (part4)

- Committee for the Greenhouse Gas Emissions Estimation Methods (the Committee)
  - The Committee's 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.
  - Inventory Working Group (crosscutting issues)
  - Breakout Group (sector-specific problem; "Energy and Industrial Processes", "Transport", "F-gas (HFCs, PFCs, SF6)", "Agriculture", "Waste", "LULUCF")

Roles and responsibilities of each entity (part5)

- GHG Inventory Quality Assurance Working Group (Expert Peer Review) (WQ-WG)
  - QA-WG is an organization that is for QA activities, comprises experts who are not directly involved in inventory compilation.
  - QA-WG's role is to assure inventory quality and to identify places that need improvement by conducting detailed reviews of each emission sources and sinks in the inventory
- Private Consulting Companies
  - QC of inventory (CRF, NIR, Spreadsheets, and other information) compiled by MOE and GIO

Questions

- Q1: Now, Which Roles and Responsibilities does the TGO administer?
- A1:
- Q2: In the Future, Which Roles and Responsibilities should the TGO administer?
- A2:

Brief Description of the Inventory Preparation Process

- The Overall Institutional Arrangement for the Inventory Preparation within Japan
- The Annual Cycle of the Inventory Preparation
- Process of the Inventory Preparation (from "Step 1" to "Step 9")
- The Inventory Improvement Process in Japan

Annual Cycle of the Inventory Preparation in Japan

*Inventory preparation in fiscal year "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

Process of the Inventory Preparation in Japan (part1)

Step 1 : Discussion on the inventory improvement	"MOE" and "GIO" identify the items, which need to be addressed by the Committee, based on the results of the previous inventory review of the UNFCCC, etc.
Step 2 : Holding the meeting of the Committee (experts)	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.
Step 3 : Collection of data for the national inventory	The data required for preparing the national inventory are collected.

Process of the Inventory Preparation in Japan (part2)

Step 4 : Preparation of a draft of CRF	The data input and estimation of emissions and removals are carried out simultaneously by utilizing files containing spreadsheets. (JNGI: Japan National GHG Inventory files)
Step 5 : Preparation of a draft of NIR	The drafts on NIR and KP-NIR prepared by following the general guidelines made by the MOE and the GIO.
Step 6 : Implementation of the exterior QC and the coordination with the relevant ministries and agencies	Exterior QC (private consulting companies check the JNGI files and the initial draft CRF) Clock-check (re-calculating the GHG) The coordination with the relevant ministries and agencies

Process of the Inventory Preparation in Japan (part3)

Step 7 : Correction of the drafts of CRF and NIR	The initial draft; possible corrections, discussion among relevant ministries (agencies) The corrected drafts; the secondary drafts. The final versions; no additional requests
Step 8 : Submission and official announcement of the national inventory	The completed inventory (MOE → Ministry of Foreign Affairs → UNFCCC Secretariat) Publication (MOE's homepage; http://www.env.go.jp, GIO's homepage; http://www-gio.nies.go.jo/index-j.html)
Step 9 : Holding the meeting of the QA-WG	QA-WG (experts who are not directly involved in or related to the inventory preparation process), Validation of estimation methodologies, activity data, emission factors, and the contents of CRF and NIR

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 data.
- Data that are not released in publications, the internet, or in other media, and unpublished data are obtained by the "MOE" or "GIO" by requesting them from the relevant ministries and agencies and relevant organization.
- The main relevant "Ministries/ Agencies/ Organization" are shown as follows;

List of the main relevant ministries and agencies and the relevant organizations

Ministry	Major data or statistics
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 the Economy, Trade and Industry	General Energy Statistics / Yearbook of Production, Supply and Demand of Petroleum, Coal and Coke / Yearbook of Iron and Steal, 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

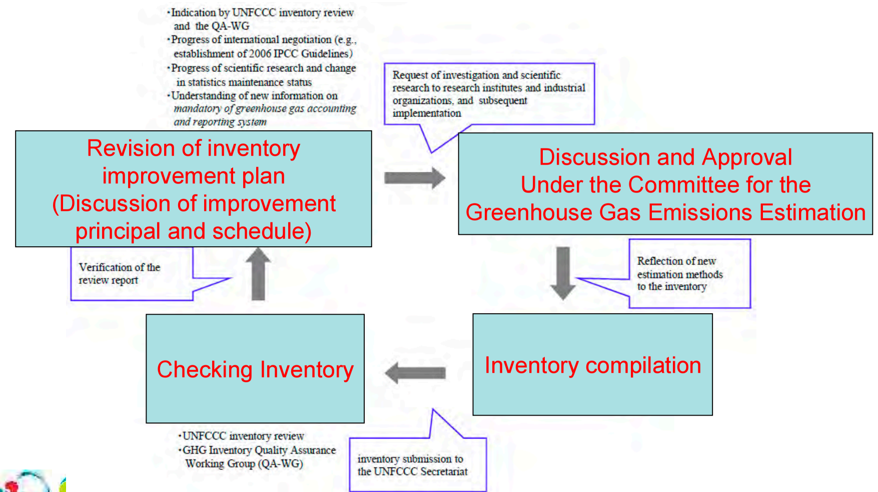
List of the main relevant ministries and agencies and the relevant organizations

Ministry	Major data or statistics
Ministry of Land, Infrastructure, Transport and Truism	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

List of the main relevant ministries and agencies and the relevant organizations

Agencies/Organizations	Major data or statistics
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

Diagram of the inventory improvement process



Improvement process of estimations for emission and removals

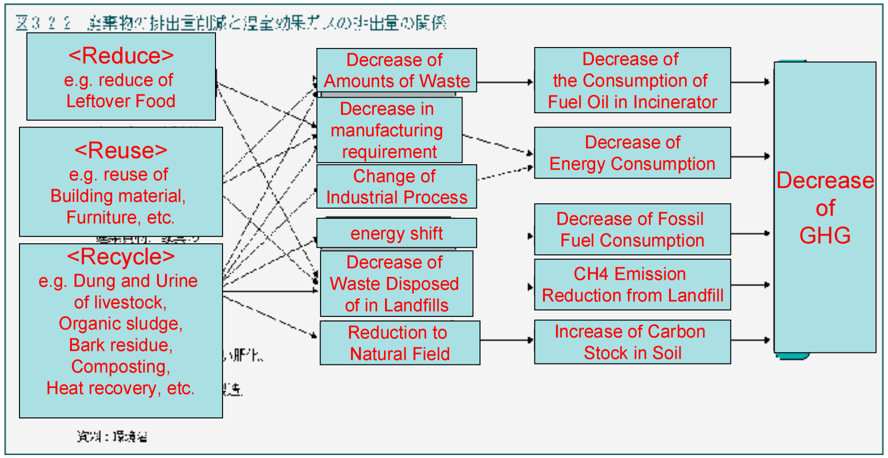
- In Japan, improvements in calculation methods are considered in accordance with necessity whenever an inventory item requiring improvement is identified because of
  - A UNFCCC review
  - An observation by the QA-WG progress
  - The creation of new guidelines
  - Progress or changes in scientific research or in compilation of statistics
  - The acquisition of new information, etc

- ありがとうございました
- ขอบคุณ มาก ครับ/ค่ะ
- Thank you very much

Home work

- In Thailand, the living standards are assumed to improve more in the near future, and at the same time, the waste quantities are assumed to increase.
- Please consider the plans to reduce GHG emissions from the Waste Sector.
- In the contemplation, also consider the environmental burden of the waste products.

Hints (relationship between)



The Project for Capacity Development and Institutional Strengthening for GHG Mitigation in the Kingdom of Thailand

Overview of QA/QC of IPCC Guideline and Example of QA/QC measures taken in Japan

January, 2011

GHG Inventory

Fumihiko KUWAHARA

Contents of "QA/QC and Verification" Training Program

1. Outline of "QA/QC and Verification"

- Glossary (What are the "QA/QC and Verification, etc."?)
- Purpose (Why does the "QA/QC and Verification" need?)
- How to use (How does the "QA/QC and Verification" use?)

Glossary (What are the "QA/QC and Verification, etc."?)

- The terms "Quality Assurance (QA)", "Quality Control (QC)" , and "Verification" are often used in different ways.
- So, the definitions of QA, QC, and Verification are used for the purposes of this guidance (2006 IPCC Guidances).

QA (Quality Assurance)

- Quality Assurance (QA)
  - QA is a **planned system of review procedures** conducted by personnel not directly involved in the inventory compilation/ development process in order to verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC programme.

QC (Quality Control)

- Quality Control (QC)
  - QC is a **system of routine technical activities** to assess and maintain the quality of the inventory as it is being compiled. It is performed by personnel compiling the inventory.
  - The QC system is designed to:
    - Provide routine and consistent checks to ensure data integrity, correctness, and completeness;
    - Identify and address errors and omissions;
    - Document and archive inventory material and record all QC activities.

Verification

- Verification
  - Verification activities include **comparisons** with emission or removal estimates prepared by **other bodies** and **comparisons** with estimates derived from **fully independent assessments**, e.g., atmospheric concentration measurements.

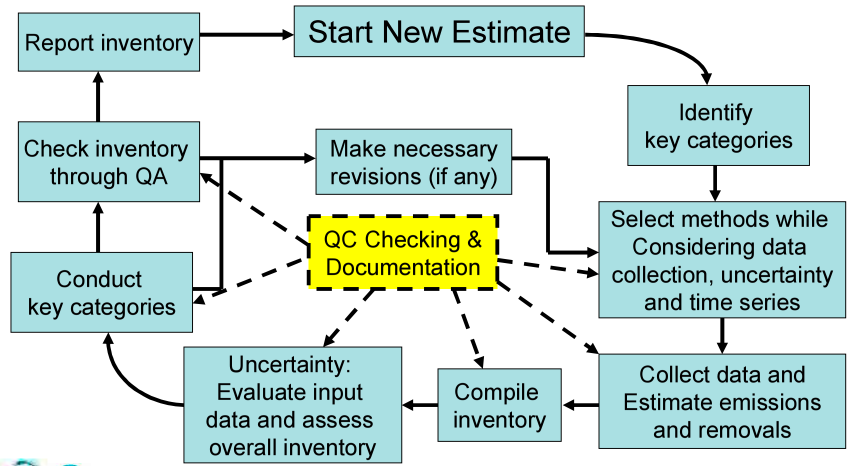
Purpose (Why does the "QA/QC and Verification" need?)

- An important goal of IPCC Guidance is to support the development of national greenhouse gas inventories that can be readily assessed in terms of quality.
- It is good practice to implement "QA/QC and Verification" procedures in the development of national GHG inventories to accomplish this goal.

How to use (How does the "QA/QC and Verification" use?)

- In practice inventory compilers **do not have unlimited resources**.
- QC requirements, improved accuracy and reduced uncertainty **need** to be **balanced** against **requirements** for **timeliness and cost effectiveness**.
- A good practice system for QA/QC and verification seeks to achieve that **balance**, and also to enable **continuous improvement** of inventory estimates.

Inventory Development Cycle



2-1. Practices (First Step of GHG Inventory)

- What should the inventory compilers do to make a preliminary assessment of a new inventory? (there are two choices)
  - 1) The inventory compilers can make a preliminary qualitative assessment based on local knowledge and expertise about large emission sources and inventories in countries with similar national circumstances.
  - 2) The inventory compilers can make preliminary Tier 1 estimates to assist in identifying key categories.

2-2. Practices (identify key category)

- Q. Once the key categories have been identified, what should the inventory compilers identify?
- A. We should identify the appropriate method for estimation for each category in the particular country circumstances.
- The selection of methods will be determined by classification of a category as key or not key, and by both data and the resources available.

2-3. Practices (data collection)

- Q. What should be considered for data collection activities?
- A. Data collection activities should consider the need for time series consistency and so data for a single year is less useful.
- A. If possible, data on uncertainties should be collected at the same time.

2-4. Practices (collect data and …?)

- Q. What should the inventory compliers do after the methodological choice and data collection?
- A. The inventory compliers should estimate emissions and removals following the methodological choice and data collection.
- A. Care should be taken to follow the general guidance on time series consistency especially if the data are incomplete for some year.

2-5. Practices (inventory estimates and …?)

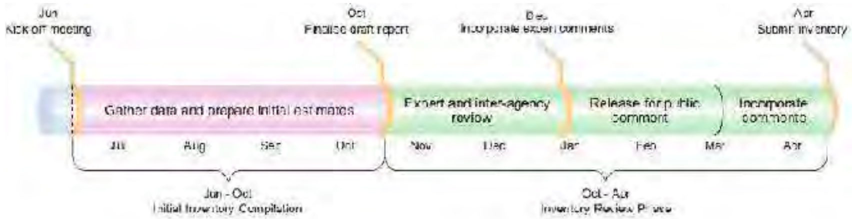
- Q. Once the inventory estimates are complete, what is the next step?
- A. Once the inventory estimates are complete, the next step is to perform an uncertainty analysis and key category analysis.
- A. These analyses may identify categories for which a higher tier should be used and additional data collected.

2-6. Practices (Check inventory)

- Q. What need to be performed, following the completion of the inventory?
- A. Following the completion of the inventory final quality assurance (QA) check need to be performed.
- A. These checks are an extremely important stage and should encompass review by stakeholders as well as parties outside the inventory process.

2-7. Practice (Inventory Development Cycle)

- In a **mature** inventory system, which step is longer, the **compilation** phase or the **review** phase?
- The **review** phase is longer than the compilation phase, because the review step is more **important**.



Example: An illustration of the timing of an annual inventory process

Source : 2006 IPCC Guidelines for national Greenhouse gas Inventories –PRIMER-

2-8. Practices (Final Step)

- Q. What is the final step in the inventory process?
- A. The final step in the inventory process is to report the inventory.
- A. The aim here is to present the inventory in an as concise and clear way as possible to enable users to understand the data, methods and assumptions used in the inventory.

3. Quality Assurance / Quality Control and Verification (from IPCC Guidelines)

- 3-1 Practical consideration in developing QA/QC and verification system
- 3-2 Elements of a QA/QC and Verification Systems
- 3-3 Roles and responsibilities
- 3-4 QA/QC plan
- 3-5 General QC procedures
- 3-6 Category-specific QC procedures
- 3-7 QA procedures
- 3-8 QA/QC and uncertainty estimates
- 3-9 Verification
- 3-10 Documentation, Archiving and Reporting

3-1 Practical consideration in developing QA/QC and verification system

- In practice inventory compiler do not have unlimited resources. QA/QC and verification system need to be balanced against requirements for timeliness and cost effectiveness.
- In order to priorities QA/QC and verification efforts, some questions should be asked to identify where to focus the categories. Some questions are given in “2006 IPCC Guidelines”.

3-2 Element of a QA/QC and Verification Systems

- Roles and Responsibilities
- A QA/QC plan (fundamental element of a QA/QC)
- General QC procedure that apply to all inventory categories
- Category-specific QC procedures
- QA and review procedures
- QA/QC system interaction with uncertainty analyses
- Verification activities
- Reporting, documentation, and archiving procedures

3-3 Roles and Responsibilities

- The inventory compiler should be responsible for coordinating the institutional and procedural arrangements for inventory activities.
- It is good practice for the inventory compiler to define specific responsibilities and procedures for the planning, preparation, and management of inventory activities, including;
  - Data collection;
  - Selection of methods, emissions factors, activity data and other estimation parameters.
  - Estimation of emissions or removals;
  - Uncertainty assessment;
  - QA/QC and verification activities;
  - Documentation and archiving.

3-4 QA/QC PLAN

- A QA/QC plan is a **fundamental element** of a QA/QC and verification system.
- The plan should, in general, outline the QA/QC and verification activities.
- The plan should include a scheduled time frame.
- The plan is an internal document to organize and implement QA/QC and verification activities.
- A key component of a QA/QC plan is the list of data quality objectives.

3-5 General QC Procedures

- General QC Procedures include generic quality check related to calculations, data processing, completeness, and documentation that are applicable to all inventory source and sink categories.
- General Inventory QC Procedures are as follows; (e.g.)
  - Check that assumptions and criteria for the selection of activity data, emission factors
  - Check for transcription errors
  - Check the calculation
  - Check the parameters and units
  - Check time series consistency, completeness and trend checks
  - Review of international documentation and archiving
  - And so on.

3-6 Category-specific QC Procedures Emission Factor QC

- Country-Specific Emission Factors
  - QC checks on the background data used to develop emission factors
  - QC checks on models
  - Comparison with IPCC default factors
  - Comparisons of emission factors between countries
  - Comparison to plant-level emission factors

3-6 Category-specific QC Procedures Activity data QC

- National Level Activity Data
  - QC checks on reference source for national activity data
  - Comparisons with independently compiled data sets
  - Comparisons with samples
  - Trend checks of activity data

3-7 Quality Assurance (QA) Procedures

- QA comprises activities outside the actual inventory compilation.
  - QA procedures include review and audits to assess the quality of the inventory, to determine the conformity of the procedures taken and to identify areas where improvements could be made.
  - Third party reviewers should be independent from the inventory compiler.

3-7 QA Procedures (Expert Peer Review)

- Expert Peer Review
  - The procedure of expert peer review does not include rigorous certification of data or references such as might be undertaken in an audit.
  - The objective is to ensure that the inventory's results, assumptions, and methods are reasonable.
  - There are no standard tools or mechanisms.
  - If there is a high level of uncertainty, expert peer review may provide information to improve the estimate or to better quantify the uncertainty.

3-7 QA Procedures (Audits)

- Audits
  - Audits may be used to evaluate how effectively the inventory complies with the minimum QC specifications outlined in the QC plan.
  - Audits do not focus on the result of calculation.
  - Audits provide an in-depth analysis of the respective procedures taken to develop an inventory, and on the documentation available.
  - Audits can be used to verify that the QC steps have been implemented, that category-specific QC procedures have been implemented according to the QC plan, and that data quality objectives have been met.

3-8 QA/QC and Uncertainty Estimates

- Staff can identify critical components of the inventory estimates and data sources. (e.g. the uncertainty level and inventory quality)
- Staff can also identify which should be a primary focus of inventory improvement efforts.
- This information should ultimately be useful in improving the methods and data sources.

3-9 Verification

- Verification activities include comparisons with emission or removal estimates prepared by other bodies and comparisons with estimates derived from fully independent assessments, e.g., atmospheric concentration measurements.
- Verification activities provide information for countries to improve their inventories.

3-9 Verification (Comparisons of national estimates)

- Applying lower tier methods
  - Lower tier IPCC methods typically are based on "top-down" approaches.
  - Inventory compiler using higher tier, "bottom-up" approaches may consider using comparisons to lower-tier methods as a simple verification tool.
- Applying higher tier methods
- Comparisons with independently compiled estimates
- Comparisons of intensity indicators between countries

3-9 Verification (Comparisons with atmospheric measurements)

- Measurements of atmospheric concentrations potentially provide the fully independent data.
- The complexity and the limited application potential of atmospheric models to inventory verification
  - Inverse Modeling
  - Continental Plumes
  - Use of Proxy Emission Databases
  - Global Dynamic Approaches

3-10 Documentation, Archiving and Reporting

- It is good practice to document and archive all information relating to the planning, preparation, and management of inventory activities.
- It is good practice to report a summary of implemented QA/QC activities and key findings as a supplement to each country's national inventory.

4. Details on Inventory Compilation System and QA/QC Plan in Japan

- 4-1 Introduction to QA/QC Plan
- 4-2 Roles and responsibilities of each entity involved in the inventory preparation process
- 4-3 Collection process of activity data
- 4-4 Selection process of emission factors and estimation methods
- 4-5 Diagram of the Inventory Improvement Process in Japan
- 4-6 QA/QC activity
- 4-7 Response for UNFCCC inventory review
- 4-8 Documentation and archiving of inventory information
- 4-9 List of the main relevant ministries and agencies and the relevant organizations

4-1 Introduction to QA/QC Plan

- The QA/QC Plan is an internal document.
  - All QA/QC activities in all processes
  - The compilation schedule
  - The apportionment of all involved entities' roles
- The Purpose of QA/QC Plan;
  - "QA/QC Plan" organizes and systematizes the QA/QC activities,
  - "QA/QC Plan" clarifies what each entity involved,
  - "QA/QC Plan" guarantees the implementation of QA/QC activities.

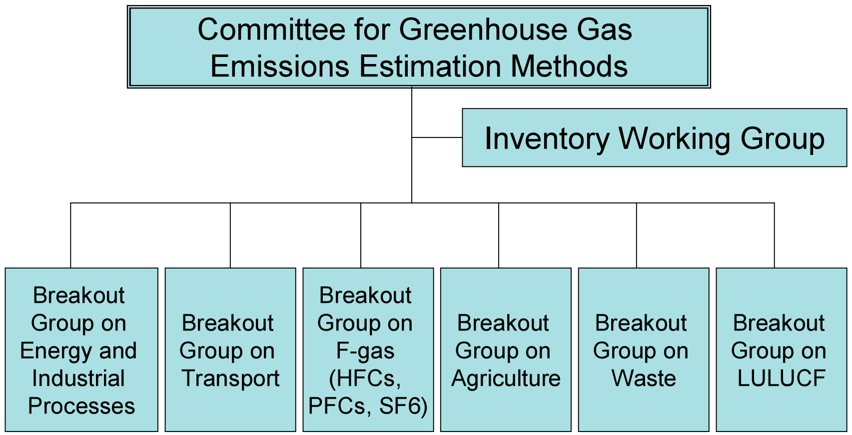
4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part1)

- MOE (Ministry of the Environment), (Climate Change Policy Division, Global Environment Bureau)
  - The single national agency responsible for preparing Japan's inventory,
  - It is responsible for editing and submitting the inventory
- GIO (Greenhouse Gas Inventory Office of Japan), (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.

4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part2)

- Relevant Ministries/Agencies
  - Preparation of activity data, emission factor data, and other data, and submission of the data by the submission deadline.
  - QC of the data
  - Confirmation and verification, and so on.
- Relevant Organizations
  - Preparation of activity data, emission factor data, and other data, and submission of the data by the submission deadline.
  - QC of the data, and so on.

4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part3)



Source: National Greenhouse Gas Inventory Report of Japan

4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part4)

- Committee for the Greenhouse Gas Emissions Estimation Methods (the Committee)
  - The Committee is a committee created and run by the MOE.
  - 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 ins the inventory working group that examines crosscutting issues, and breakout groups that consider sector-specific problems.

4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part5)

- GHG Inventory Quality Assurance Working Group (the QA-WG) (Expert Peer Review)
  - 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 identify places that need improvement..
- Private Consulting Companies
  - QC of inventory (CRF, NIR, spreadsheets, and other information), and so on.

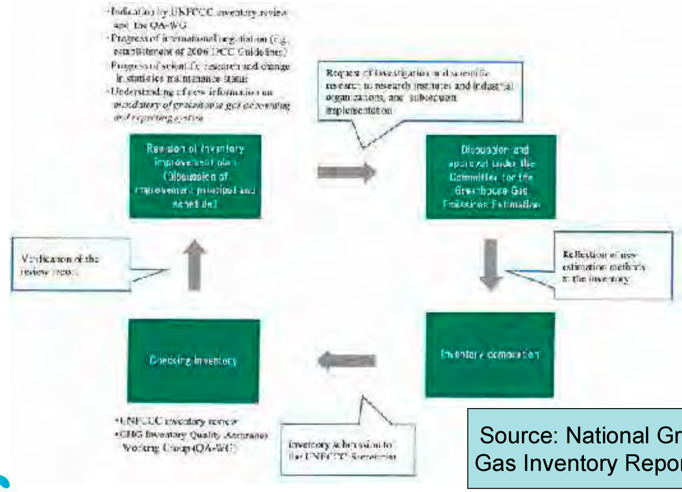
4-3 Collection process of activity data

- If the activity data are available from sources such as publications and the internet, these data are gathered from these media.
- If the activity data are not released in publications, the internet, or other media, these data are obtained by the MOE or the GIO by requesting them from the relevant ministries and agencies and the relevant organization which control those data.

4-4 Selection process of emission factors and estimation methods

- Based on
  - 1996 Revised IPCC Guideline
  - GPG(2000)
  - GPG-LULUCF
  - 2006 IPCC Guideline
- Calculation methods are determined by having the Committee explore calculation methods suited to Japan's situation for all the activity categories.

4-5 Diagram of the Inventory Improvement Process in Japan



Source: National Greenhouse Gas Inventory Report of Japan

4-6 Summary of Japan's QA/QC activity (Quality Control Part1)

Implementing entity	Main contents of activity
Ministry of Environment (Climate Change Policy Division, Global Environment Bureau)	•Progress management of the inventory compilation and over all control •Check of inventory compiled by the GIO (CRF, NIR, spreadsheets, and other information) •Establishment and inventory improvement plan •Check of the inventory improvement plan •Holding the meeting of the Committee for the Greenhouse Gas Emissions Estimation Methods

4-6 Summary of Japan's QA/QC activity (Quality Control Part2)

Implementing entity	Main contents of activity
Greenhouse Gas Inventory Office of Japan, Center for Global Environmental Research, National Institute for Environmental Studies (GIO)	•QC Check in inventory compilation •Archiving of QA/QC activity records and relevant data and documents •Development of information system •Making of inventory improvement plan •Making of revised QA/QC plan

4-6 Summary of Japan's QA/QC activity (Quality Control Part3)

Implementing entity	Main contents of activity
Relevant Ministry and Agencies (including the Ministry of the Environment) and relevant organization	•Preparation of activity data, emisson factor, and other data needed for inventory compilation, and submission of the data by the submission deadline •Check of various data supplying to the GIO •Check and validation of inventory compiled by GIO (CRF, NIR, spreadsheets, and other information)

4-6 Summary of Japan's QA/QC activity (Quality Control Part4)

Implementing entity	Main contents of activity
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)

4-6 Summary of Japan's QA/QC activity (Quality Assurance)

Implementing entity	Main contents of activity
Inventory Quality Assurance Working Group (QA-WG) (Expert Peer Review)	•Validation of estimation methods, emission factors, and activity data •Inventory assessment

4-6 QA Activity in Japan

- 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 (QA WG; Expert Peer Review)
  - 2. Internal QA (consists of inventory checking by staff members who are not among the SE responsible for each category.)
  - 3. UNFCCC inventory review

4-6 QA-WG (Expert Peer Review)

- 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.
- QA-WG in FY 2009
  - The QA-WG was newly established in FY 2009.
  - The reviewed sectors were the Agriculture and the Waste Sectors (two experts for the Agriculture and one experts for the Waste) in FY 2009.
  - Key data and methods of estimation used in these sectors have been validated by QA-WG.

4-7 Response for UNFCCC inventory review

- The MOE is assigned to be the agency with overall control (responsibility) for review response.
- 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 that are involved in inventory compilation cooperate with review response.

4-8 Documentation and archiving of inventory information

- In Japan, the information needed for inventory compilation is documented and as a rule archived by GIO.
- Documentation of information
  - 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 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.
  - Records of communications with related entities
  - Record of QA/QC activities conducted, etc.

4-9 List of the main relevant ministries and agencies and the relevant organizations

Ministry	Major data or statistics
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 the 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

4-9 List of the main relevant ministries and agencies and the relevant organizations

Ministry	Major data or statistics
Ministry of Land, Infrastructure, Transport and Truism	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

4-9 List of the main relevant ministries and agencies and the relevant organizations

Agencies/Organizations	Major data or statistics
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

5. The example of each country's QA procedure

- The QA procedures of each country such as U.S.A., the U.K., EU, Canada, the Netherlands and Japan are shown below.
- These now may have been changed, because their results were examined in Japan in 2008.

QA/QC Basic Structure of Japanese National System (part1)

	Japan
Implementing entity of QC	Ministry of the Environment (MOE)/ Ministry of Economy, Trade and Industry/ Ministry of Land, Infrastructure, Transport and Tourism/ Ministry of Agriculture, Forestry and Fisheries/ Ministry of Health, Labour and Welfare/ the staff of the relevant organizations/ inventory compiler
Implementing entity of QA	Committee for the Greenhouse Gas Emissions Estimation Methods (the experts who are outside the inventory compilation system)
Coordinator of QA	MOE (the agency which is responsible for editing and submitting the inventory)

QA/QC Basic Structure of Japanese National System (part2)

	Japan
Administrator of QA	The staffs of MOE, GIO and Private Consultant Companies
Item of evaluation	Summary of the Inventory, Draft Inventory and the items which change by the report of relevant year
Method of executing evaluation activity	The committee for ""GHG Emissions Estimation Methods"" is held. Or information is sent to the expert, and the confirmation is requested to the expert. Individual matters consult experts at any time. Improvement suggestions are considered once more by the Committee before approval.

QA/QC Basic Structure of Japanese National System (part3)

	Japan
Schedule of QA activity	"It's held at any time as the need arises. When the inventory is fixed, the committee for ""GHG emissions estimation methods"" is held and give approval. "
Overall control of information / Documentation of information	It is implemented by the staffs of MOE, GIO and Private Consultant Companies.

QA/QC Basic Structure of U.S.A. National System (part1)

	The United States of America
Implementing entity of QC	United States Environmental Protection Agency (EPA), the United States Department of Energy (DOE), the United States Department of Agriculture (USDA), the staff of the relevant organizations, individual source leads, inventory compiler
Implementing entity of QA	The experts who are outside the inventory compilation system

QA/QC Basic Structure of U.S.A. National System (part2)

	The United States of America
Coordinator of QA	EPA (responsible authorities of GHG Inventory)
Administrator of QA	The QA/QC and Uncertainty coordinators
Item of evaluation	Data Gathering and Input, Documentation, and Calculation Summary of the Inventory, Draft Inventory and the items which change by the report of relevant year

QA/QC Basic Structure of U.S.A. National System (part3)

	The United States of America
Method of executing evaluation activity	First Draft of document: Expert Review (technical experts outside of EPA) Second Draft of document: Public Review (publish a notice in the U.S. Federal Register and post on the EPA Web site) After the final revisions to incorporate any comments, EPA prepares the final NIR.
Schedule of QA activity	It is carried out every year from the middle of November to the end of December.
Overall control of information / Documentation of information	The QA/QC and Uncertainty Coordinators

QA/QC Basic Structure of U.K. National System (part1)

	The United Kingdom
Implementing entity of QC	Inventory Agency: AEA of AEA Technology plc – under contract with the Climate, Energy, Science and Analysis (CESA) Division in the UL Department of Energy and Climate Change (DECC)
Implementing entity of QA	Lloyds and the AEA Technology internal QA auditors
Coordinator of QA	AEA (part of AEA Technology plc)

QA/QC Basic Structure of U.K. National System (part2)

	The United Kingdom
Administrator of QA	There is no clear description.
Item of evaluation	Peer reviews by experts outside; the method for estimating emissions from each target sector Auditors; on authorization of personnel to work on inventories, document control, data tracking, and spreadsheet checking, and project management
Method of executing evaluation activity	The evaluated sector is set every year. The external experts estimate the method of emission from this target sector.

QA/QC Basic Structure of U.K. National System (part3)

	The United Kingdom
Schedule of QA activity	On three occasions in the last ten years 2002 (CO_2 emissions from fossil fuel) 2005 (Agriculture)
Overall control of information / Documentation of information	A list collating and prioritizing improvements identified by the Inventory Agency, and from Expert and Peer Reviews, is maintained by the Inventory Agency.
Others	None

QA/QC Basic Structure of Canada's National System (part1)

	Canada
Implementing entity of QC	The Greenhouse Gas Division of Environment Canada (Environment Canada)
Implementing entity of QA	EPWG (Emissions and Projections Working Group) (It consists of experts)
Coordinator of QA	The Greenhouse Gas Division of Environment Canada

QA/QC Basic Structure of Canada's National System (part2)

	Canada
Administrator of QA	The Greenhouse Gas Division of Environment Canada
Item of evaluation	Summary of the Inventory Draft Inventory Procedures of the calculation of GHG Greenhouse Gas Emission Trends
Method of executing evaluation activity	Every year, a federal/provincial/territorial group of experts (the Emissions and Projections Working Group of the National Air Issues Committee) implements evaluation activity.

QA/QC Basic Structure of Canada's National System (part3)

	Canada
Schedule of QA activity	There is no clear description.
Overall control of information / Documentation of information	"Environment Canada's Greenhouse Gas Division"
Others	The components of inventory are externally reviewed by experts, government agencies and provincial and territorial government agencies and provincial and territorial governments.

QA/QC Basic Structure of Netherland's National System (part1)

	Netherland
Implementing entity of QC	TNO (Netherlands Organization for Applied Scientific Research) RIVN (National Institute of Public Health and Environment)
Implementing entity of QA	VROM (Netherlands Ministry of Spatial Planning, Housing and the Environment)の検査官室
Coordinator of QA	TNO (Netherlands Organization for Applied Scientific Research)
Administrator of QA	There is no clear description.

QA/QC Basic Structure of Netherland's National System (part2)

	Netherland
Item of evaluation	Summary of the Inventory Draft Inventory Collection of data Validation Archiving of information / data management Spread enlightenment of data
Method of executing evaluation activity	All procedures and processes of the QA/QC program are established to meet the national system requirements (as part of the annual activity program of the Netherlands PRTR (the Netherlands Pollutant Release & Transfer Register).

QA/QC Basic Structure of Netherland's National System (part3)

	Netherland
Schedule of QA activity	A peer and public review on the basis of the draft NIR in January/February.
Overall control of information / Documentation of information	TNO (Netherlands Organization for Applied Scientific Research)
Others	None

- ありがとうございました
- ขอบคุณ มาก ครับ/ค่ะ
- Thank you very much