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

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GHG Inventory

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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

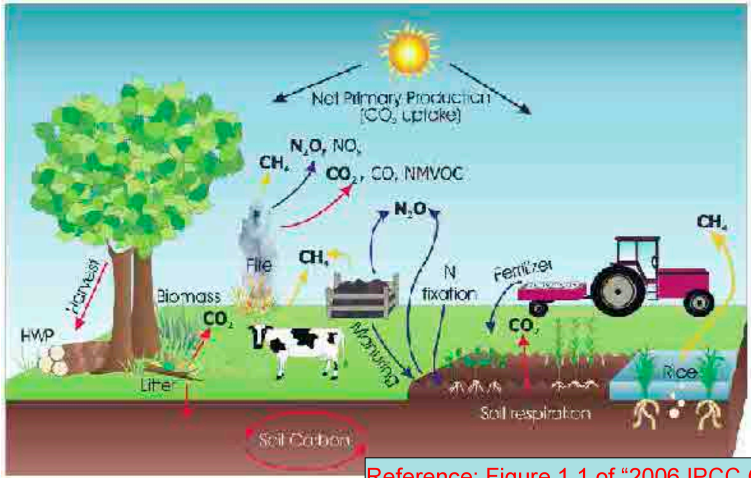
What is "Managed Land"?

- 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

Total emissions from a 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.

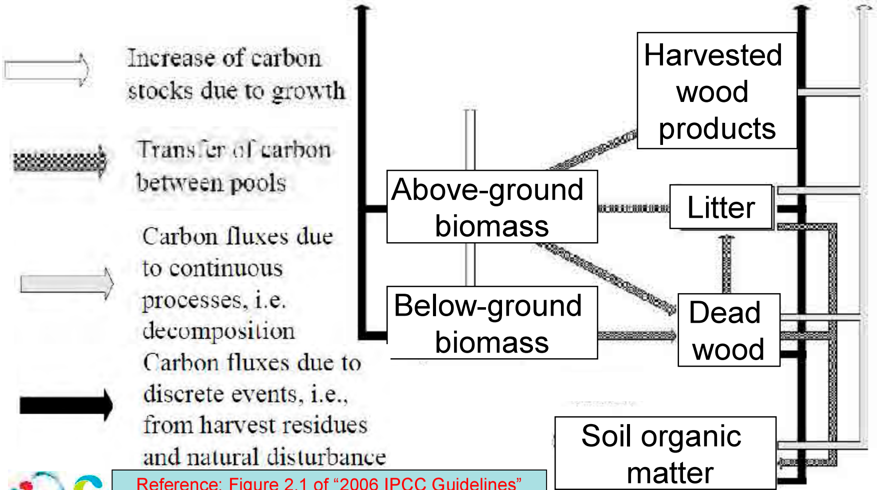
Data Sources of Land-Use

- 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	5	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		Climate region	Ecological zone		
Domain	Domain criteria		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)

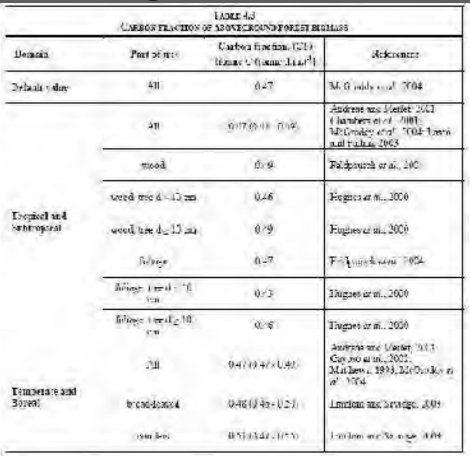


TABLE 4.3
CARBON FRACTION OF ABOVEGROUND FOREST BIOMASS

Domain	Part of tree	Carbon fraction, (CF) [tonne C (tonne d.m.)$^{-1}$]	References
Default value	All	0.47	[illegible]
Tropical and Subtropical	All	[illegible]	[illegible]
	wood	[illegible]	[illegible]
	wood, tree d < 10 cm	0.46	Hughes et al., 2000
	wood, tree d ≥ 10 cm	[illegible]	Hughes et al., 2000
	foliage	[illegible]	[illegible]
	foliage, tree d < 10 cm	[illegible]	Hughes et al., 2000
	foliage, tree d ≥ 10 cm	[illegible]	Hughes et al., 2000
Temperate and Boreal	All	[illegible]	[illegible]
	broad-leaved	[illegible]	[illegible]
	conifers	[illegible]	[illegible]

Source: 2006 IPCC Guideline Volume 4 Figure 4.3

Practice1 (Biomass loss)

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

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)
- Δ$L_{wood\text{-}removals}$ = 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 (m3)			
	<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)
- Δ$L_{wood\text{-}removals}$ = 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) ;
- $\Delta L_{wood\text{-}removals}$ = 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				

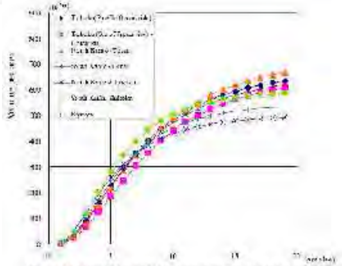


Figure 7-2 Yield tables made by forest resources monitoring survey data (Japanese cedar : 7 areas)

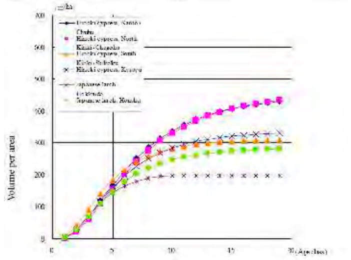


Figure 7-3 Yield tables made by forest resources monitoring survey data (Hinoki cypress : 4 areas, Japanese larch : 2 areas)

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.

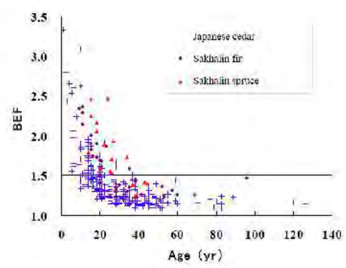


Figure 7-4 Biomass expansion factor related with forest age

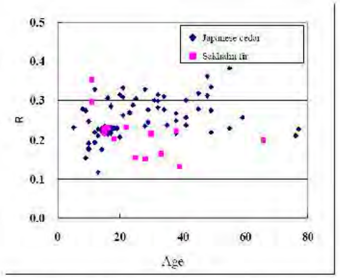


Figure 7-5 Root-to-shoot ratio (R), tree species, forest age

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)

		BEF ≦20	BEF >20	R	D	CF	Note
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	1.24	1.38	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		Japanese zelkova Cercidiphyllum
	Momi fir	Other broad leaf	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)

A1-286

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.

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

ΔC_{ds} : 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.

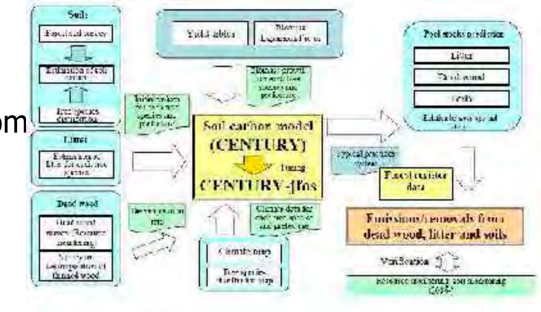


Figure 7-6 Estimation of removals in dead wood, litter and soils

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	-406.9	-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	81.8	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.

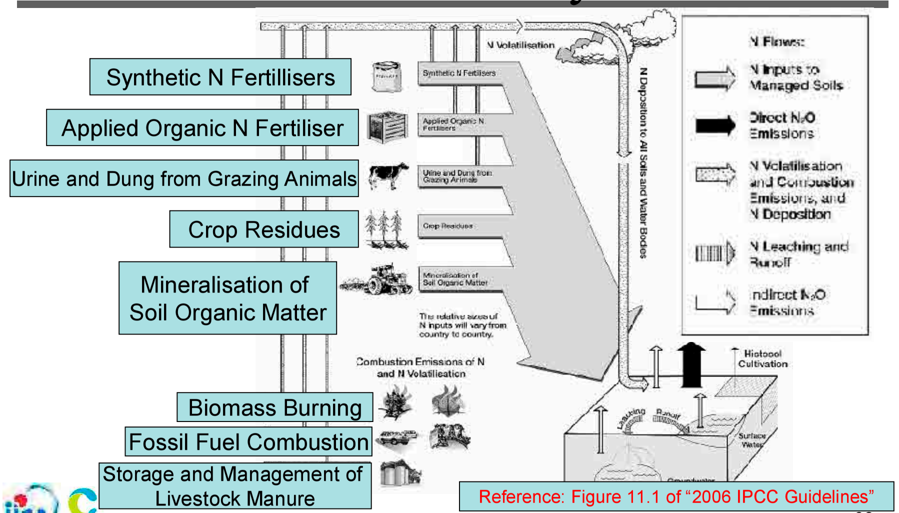
N2O Emission from Managed Soils, and CO2 Emissions from Lime and Urea Application

- 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 N2O Emissions, Indirect N2O 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

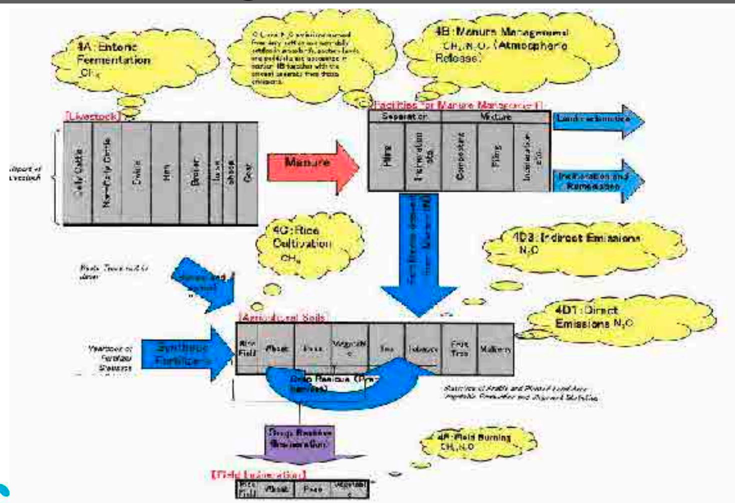
Land Use Transition Matrix for Japan in FY2008 (unit: kha) (Approach 2)

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)

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

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
[illegible]	[illegible]	0.71	0.14	406	406	0	4,010	339	226
[illegible]	[illegible]	0.71	0.14	[illegible]	384	0	4,046	345	230
[illegible]	7,481	0.71	0.14	369	369	0	1,068	348	232
[illegible]	7,201	0.71	0.14	355	355	0	1,074	350	233
[illegible]	[illegible]	0.71	0.14	326	326	0	4,050	351	234
[illegible]	[illegible]	0.71	0.14	308	308	0	4,008	349	232
1999	[illegible]	0.71	0.14	295	295	0	3,959	345	230
2000	[illegible]	0.71	0.14	[illegible]	[illegible]	0	[illegible]	341	227
2001	[illegible]	0.71	0.14	270	270	0	[illegible]	336	224
2002	4,967	0.71	0.14	245	245	0	[illegible]	330	220
2003	[illegible]	0.71	0.14	229	229	0	[illegible]	323	215
2004	4,451	0.71	0.14	220	220	0	[illegible]	315	210
2005	4,032	0.71	0.14	199	199	0	3,450	307	204
2006	[illegible]	0.71	0.14	[illegible]	[illegible]	0	[illegible]	297	198
2007	[illegible]	0.71	0.14	[illegible]	[illegible]	0	[illegible]	288	192

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 = ln2/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 last year * 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 = ln2/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 last year * 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	[illegible]	93
1994	8,000	0.72	429	429	0	2,265	173	110
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

$$E = \left\{ \sum \left(EF_{i,j} \times A_{i,j} \right) - R \right\} \times \left(1 - OX \right)$$

- 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		- *	—
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 percentages 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)	1,246	1,1[illegible]5	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	337	333	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".

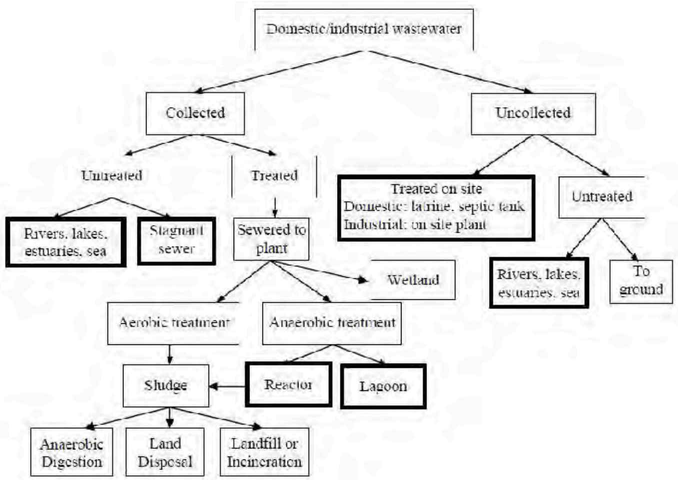
5. Wastewater Treatment and Discharge

- 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

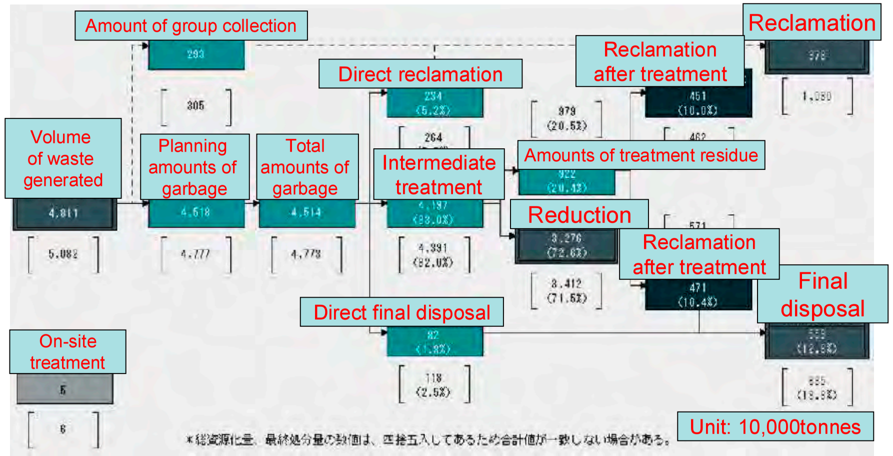
Question (about Wastewater Treatment)

- 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.

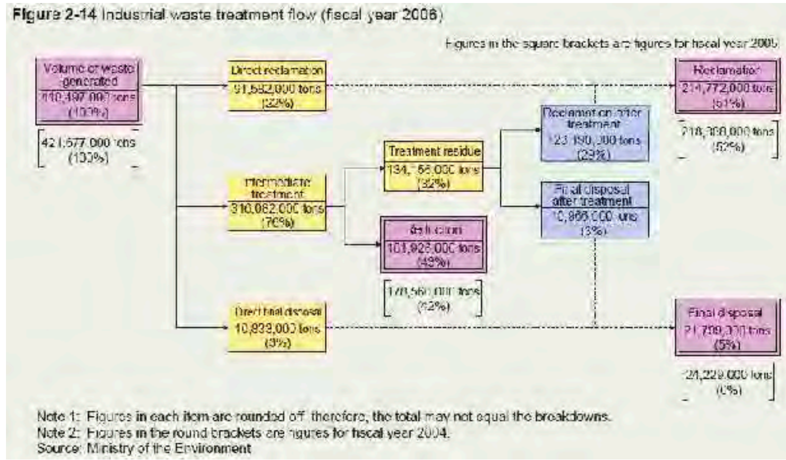
Outline of the GHG from Waste Sector in Japan

- 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)”

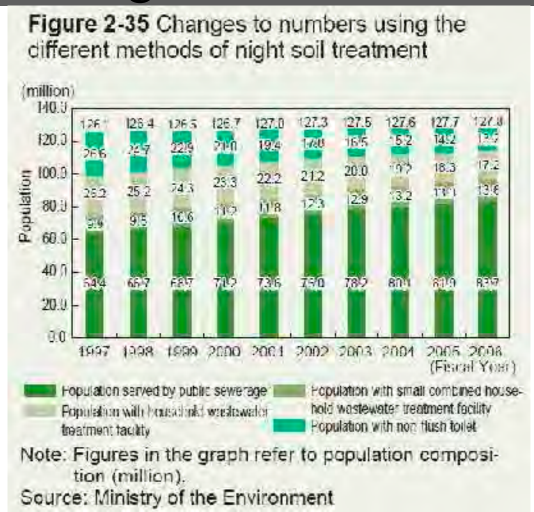
Japan's Waste Flow (Municipal Waste (excluding Industrial Waste); 2008)



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)

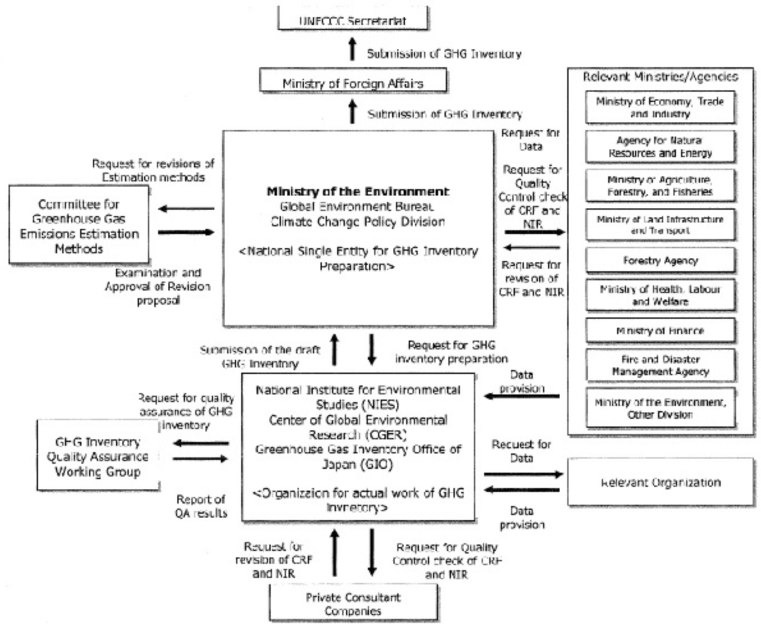
Thailand	Domestic wastewater : 1.77 (CH4 Gg) Industrial wastewater : 13.88 (CH4 Gg)
Malaysia	Domestic/Commercial wastewater :3.5 (CH4 Gg) Industrial wastewater : 220 (CH4 Gg)
Indonesia	402 (CH4 Gg) * Waste/Landfill (The detail is unclear.)
Philippine	Domestic/Commercial wastewater :46.02 (CH4 Gg) Industrial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

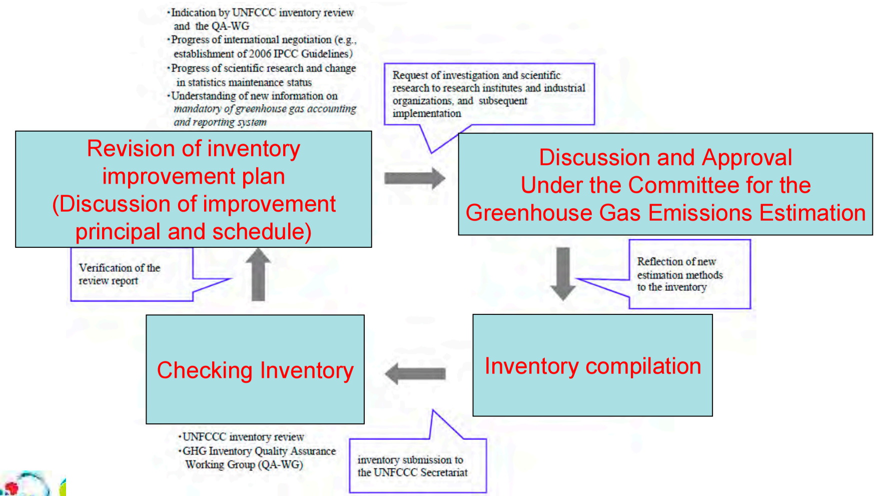
List of the main relevant ministries and agencies and the relevant organizations

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

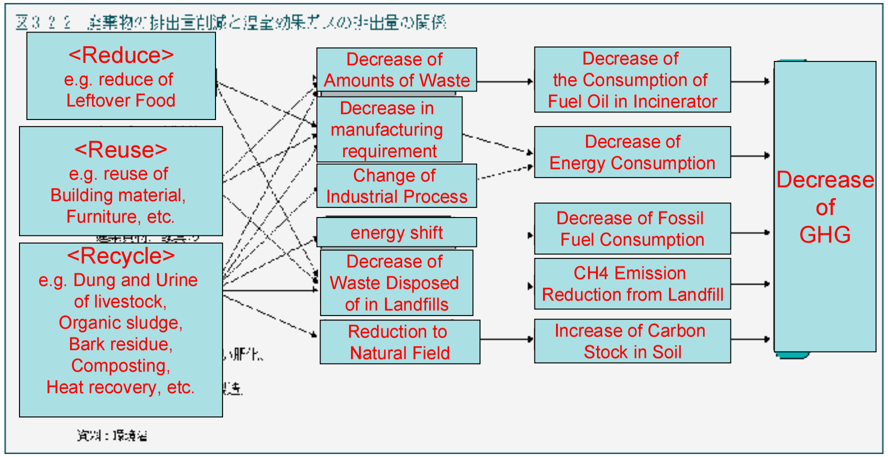
- In Japan, improvements in calculation methods are considered in accordance with necessity whenever an inventory item requiring improvement is identified because of
  - A UNFCCC review
  - An observation by the QA-WG progress
  - The creation of new guidelines
  - Progress or changes in scientific research 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 (Quality Assurance / Quality Control) and Verification"
- 2. Practice
- 3. Quality Assurance / Quality Control and Verification (from IPCC Guidelines)
- 4. Details on Inventory Compilation System and QA/QC Plan in Japan
- 5. The example of each country's QA procedure

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.

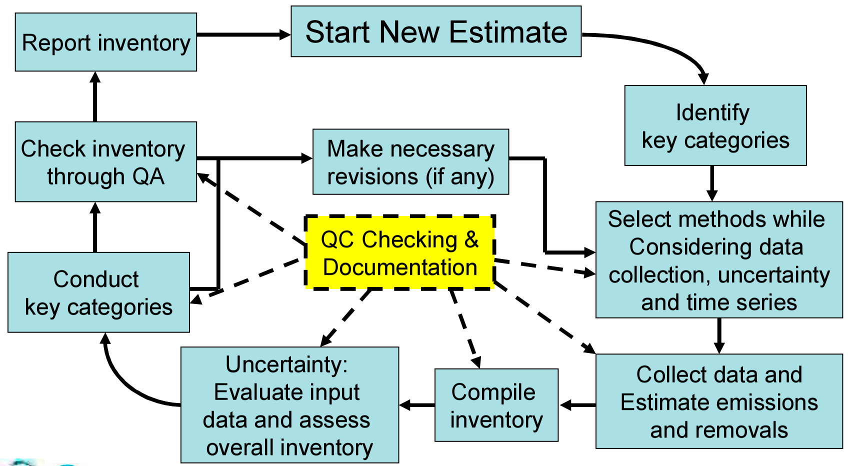
Purpose (Why does the "QA/QC and Verification" need?)

- 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.

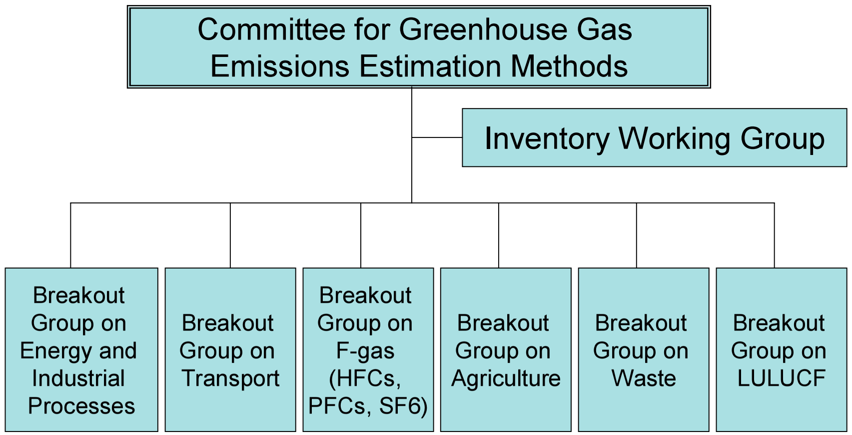
4-2 Roles and responsibilities of each entity involved in the inventory preparation process (part1)

- 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.

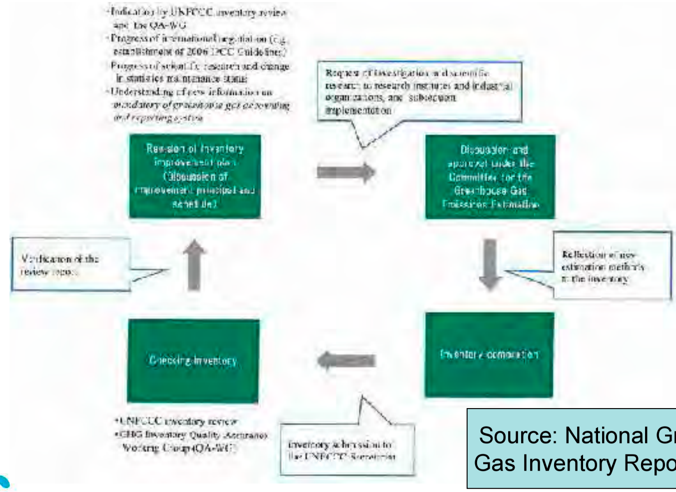
4-3 Collection process of activity data

- 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

Analysis of Key Categories and Assessment of Uncertainties, Example from Japanese Cases

February, 2011

GHG Inventory
Fumihiko KUWAHARA

Contents of "Key Categories and Uncertainties" Training Program

- 1. Uncertainties
- 2. Japan's Case of Uncertainties
- 3. Key Categories
- 4. Japan's Case of Key Categories

1. Uncertainties

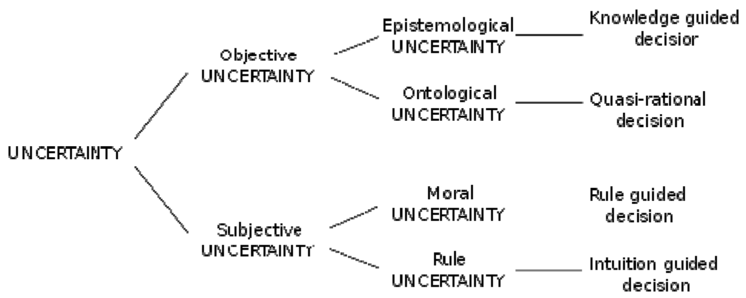
- 1-1 What is the "Uncertainty"?
- 1-2 The cause of the "Uncertainties"
- 1-3 The reason to use "Uncertainties" in GHG Inventory
- 1-4 Application of "Uncertainties" in GHG Inventory
- 1-5 The method of estimation of "Uncertainties" in GHG Inventory

1-1 What is the "Uncertainty"?

- Uncertainty: Lack of knowledge of the true value of a variable that can be described as a probability density function characterizing the range and likelihood of possible values.
- Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods.
- It is assumed that no one knows the true value.

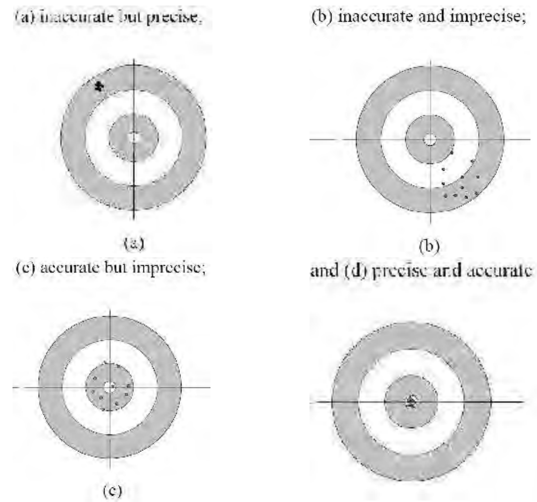
1-2 The cause of the "Uncertainties"

- "Uncertainties" can be generally classified as follows.



Source: http://en.wikipedia.org/wiki/Uncertainty

Illustration of Accuracy and Precision



Source; 2006 IPCC Guidelines for National Greenhouse Gas Inventories

1-2 Other Comments

- Please refer "2006 IPCC Guidelines", "EMEP/EEA air pollutant emission inventory guidebook 2009" and "Mathematics textbook" (e.g. "Guide to the Expression of Uncertainty in Measurement" (ISO, Revised 1995)), about some details of "Uncertainty" (such as the concept, formula, etc.).
- Quantitative uncertainty (in some case)

1-3 The Reason to use "Uncertainties" in GHG Inventory

- Uncertainty estimates are an essential element of a complete inventory of GHG emissions and removals.
- An uncertainty analysis helps prioritise national efforts to reduce the uncertainty of inventory in the future and guide decisions on methodological choice.

1-4 Application of Uncertainties in GHG Inventory

- Uncertainty Estimates
  - National level and trend estimate
  - Component parts such as Emission Factors (EFs), Activity Data (AD) and other parameters
- Key Category Analysis
  - A key category is on that is prioritised within national inventory system because its estimate has a significant influence on a country’s total inventory of GHG in terms of the absolute level, the trend, or the uncertainty.
  - A key category is described below (next sector of this session)

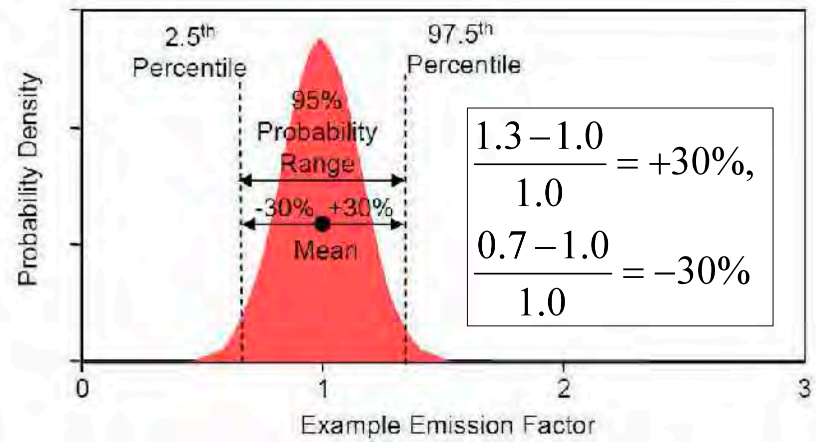
1-5 The method of estimation of “Uncertainties” in GHG Inventory

- Approach 1: Propagation of Error
- Approach 2: Monte Carlo Simulation

Overview of Uncertainty Analysis

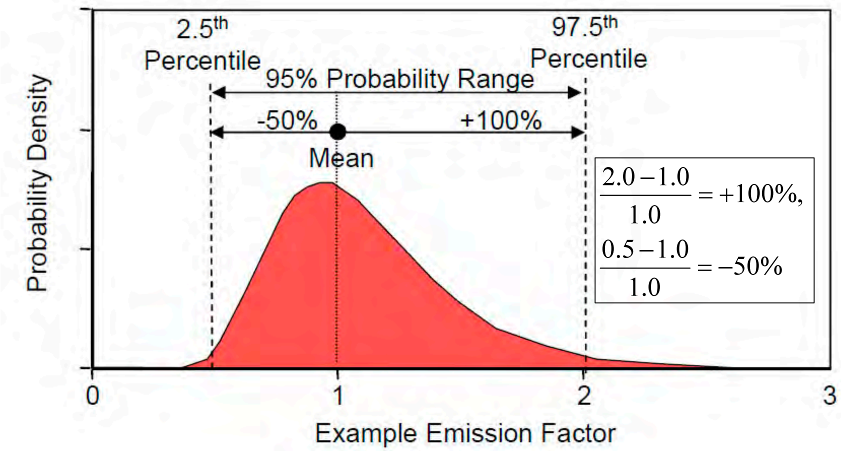
- Uncertainty Estimates are an essential element
  - Determining uncertainties in individual variables
  - Aggregating the component uncertainties
  - Determining the uncertainty in the trend
  - Indentifying significant sources of uncertainty
- Some uncertainty (not statistical means) is important
  - Omissions or double counting, or other conceptual errors, incomplete understanding of the processes, etc…
- Quantitative uncertainty analysis
  - 95% confidence interval of the emissions and removals estimate for individual categories and the total inventory

Example of a symmetric uncertainty of 30 % relative to the mean



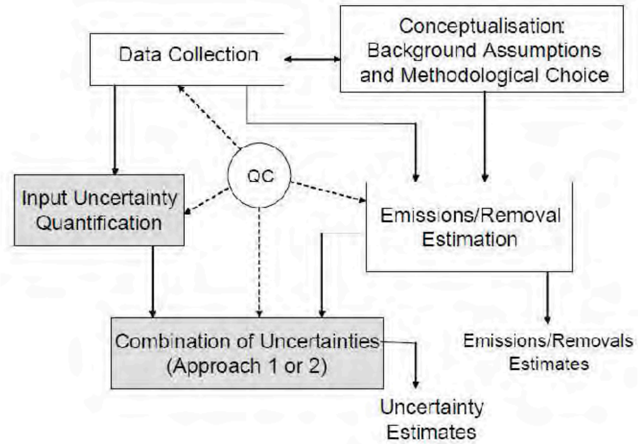
Source: 2006 IPCC Guidelines Volume 1: General Guidance and Reporting

Example of an asymmetric uncertainty of -50% to +100% relative to the mean, or factor of two



Source: 2006 IPCC Guidelines Volume 1: General Guidance and Reporting

Overall Structure of Uncertainty Analysis



Source: 2006 IPCC Guidelines Volume 1: General Guidance and Reporting

Basic Equation of "Uncertainties"

- Multiplication: A1 x A2 (e.g. combine EF AD parameter)

$$U_A = \sqrt{U_{A1}^{\ 2} + U_{A2}^{\ 2}}$$

- Addition and Subtraction: A1 + A2 (e.g. overall uncertainty in national inventory)

$$U_{A\text{-total}} = \frac{\sqrt{(U_{A1} \times A_1)^2 + (U_{A2} \times A_2)^2}}{A_1 + A_2}$$

Example of Emission Factor Uncertainties (from 2006 IPCC Guidelines)

TABLE 2.2
DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE ENERGY INDUSTRIES
(kg of greenhouse gas per TJ on a Net Calorific Basis)

Fuel		CO_2			CH_4			N_2O		
		Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper
Crude Oil		73 300	71 100	75 500	r 3	1	10	0.6	0.2	2
Orimulsion		r 77 000	69 300	85 400	r 3	1	10	0.6	0.2	2
Natural Gas Liquids									0.2	2
Gasoline	Motor Gasoline								0.2	2
	Aviation Gasoline								0.2	2
	Jet Gasoline								0.2	2
Jet Kerosene		r 71 500	69 700	74 400	r 3	1	10	0.6	0.2	2
Other Kerosene		71 900	70 800	73 700	r 3	1	10	0.6	0.2	2
Shale Oil		73 300	67 800	79 200	r 3	1	10	0.6	0.2	2
Gas/Diesel Oil		74 100	72 600	74 800	r 3	1	10	0.6	0.2	2

$$\frac{75500-73300}{73300} \approx +3\%, \quad \frac{71100-73300}{73300} \approx -3\%$$

Source: 2006 IPCC Guidelines Volume 2: Energy

Example of Activity Data Uncertainties

TABLE 2.15
LEVEL OF UNCERTAINTY ASSOCIATED WITH STATIONARY COMBUSTION ACTIVITY DATA

Sector	Well developed statistical systems		Less developed statistical systems	
	Surveys	Extrapolation	Surveys	Extrapolation
Main activity electricity and heat production	Less than 1%	3-5%	1-2%	5-10%
Commercial, institutional, residential combustion	3-5%	5-10%	10-15%	15-25%
Industrial combustion (Energy intensive industries)	2-3%	3-5%	2-3%	5-10%
Industrial combustion (others)	3-5%	5-10%	10-15%	15-20%
Biomass in small sources	10-30%	20-40%	30-60%	60-100%

The inventory compiler should judge which type of statistical system best describes their national circumstances.
Source: IPCC *Good Practice Guidance* and Uncertainty Management in National Greenhouse Gas Inventories (2000)

Source: 2006 IPCC Guidelines Volume 2: Energy

Example of Combined Uncertainty

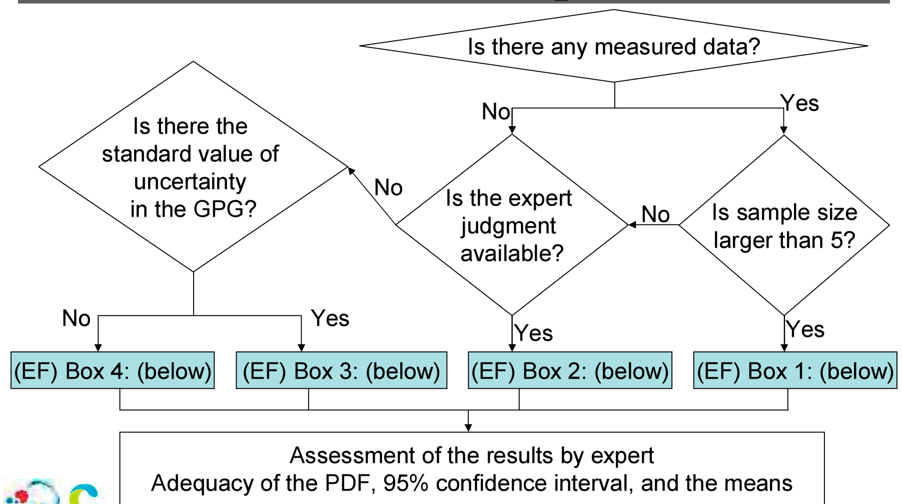
	Emissions (Gg CO2/year)	Activity Data Uncertainty (%)	EF Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category
Source 1	E1	U_{A1}	U_{EF1}	$CU1 = \sqrt{U_{A1}^2 + U_{EF1}^2}$	$CV1 = \frac{(CU1 \times E1)^2}{(E1+E2+E3)^2}$
Source 2	E2	U_{A2}	U_{EF2}	$CU2 = \sqrt{U_{A2}^2 + U_{EF2}^2}$	$CV2 = \frac{(CU2 \times E2)^2}{(E1+E2+E3)^2}$
Source 3	E3	U_{A3}	U_{EF3}	$UC3 = \sqrt{U_{A3}^2 + U_{EF3}^2}$	$CV3 = \frac{(CU3 \times E3)^2}{(E1+E2+E3)^2}$
Total	E1+E2+E3				$\sqrt{CV1 + CV2 + CV3}$

Percentage uncertainty in total Inventory

Uncertainty Assessment Condition in Japan

- Japan has a lot of emission factor data and detailed activity data.
- The uncertainty are estimated based on these data.
- However, there are not enough data which the "Uncertainties" are assessed completely.
- Therefore, the "Uncertainties" are estimated by setting some assumptions and conditions.

Decision tree for assessing uncertainty associated with EFs (Japanese Case)



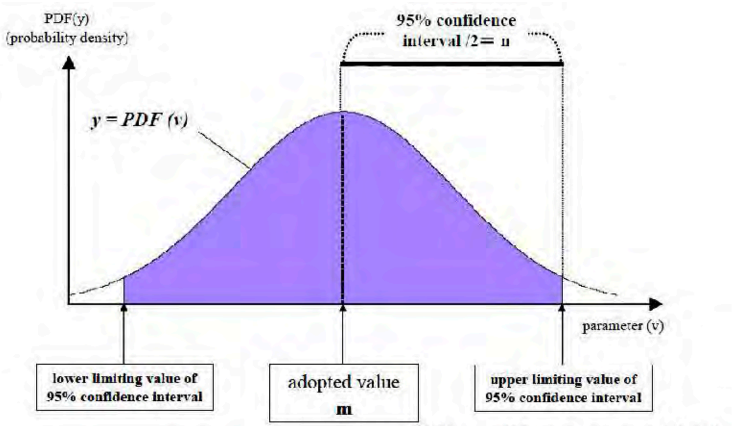
(EF) Box 1 : Case where is measurement data with five or more samples

- The uncertainty is assessed quantitatively
  - Guideline 1 : Assuming that all averages $\bar{x}$ and standard deviations $\sigma/\sqrt{n}$ follow a normal distribution curve.
  - Guideline 2 : Assuming that systematic error inherent to individual items of data is already a factor in the distribution.
  - Guideline 3 : Items that may contribute to uncertainty, but which may not be readily quantitatively assessable, should be recorded for the future investigation. If, through expert judgment, it is possible to estimate their uncertainty, the uncertainty should be estimated in accordance with expert judgment.

(EF) Box 2 : When Expert Judgment is feasible (no actual measurement data or less than five samples)

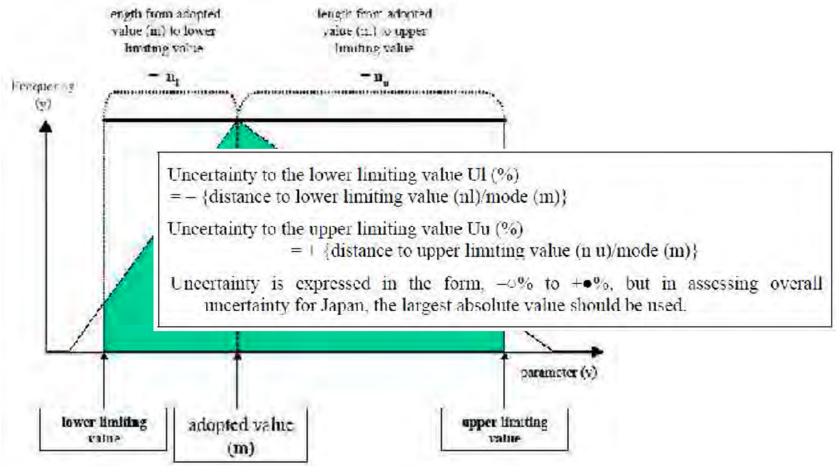
- When the distribution of the probability density function of emission factors can be obtained using expert judgment
  - Distribution and evidence
  - Upper and lower limiting values
  - Upper and lower limiting values of 95% confidence interval
  - Mean, first, and third quartile value
- When the distribution of the probability density function of emission factors cannot be obtained using expert judgment
  - Upper and lower limiting values, adopted value (EF used)
  - Triangular distribution

When the distribution of the probability density function of emission factors can be obtained using expert judgment



$$\text{Uncertainty of EF or A} = \frac{\text{95\% confidential interval / 2 (u)}}{|\text{Adopted Value of EF or E (m)}|}$$

When the distribution of the probability density function of emission factors cannot be obtained using expert judgment



(EF) Box 3 : "When expert judgment is not possible" and "A standard value for uncertainty is provided in GPG"

- When the Good Practice Guidance (2000) provides a standard value for uncertainty for a particular emission source, an estimate of uncertainty should err on the safe side, and the upper limiting value of the standard uncertainty value given in the Good Practice Guidance (2000) should be used.

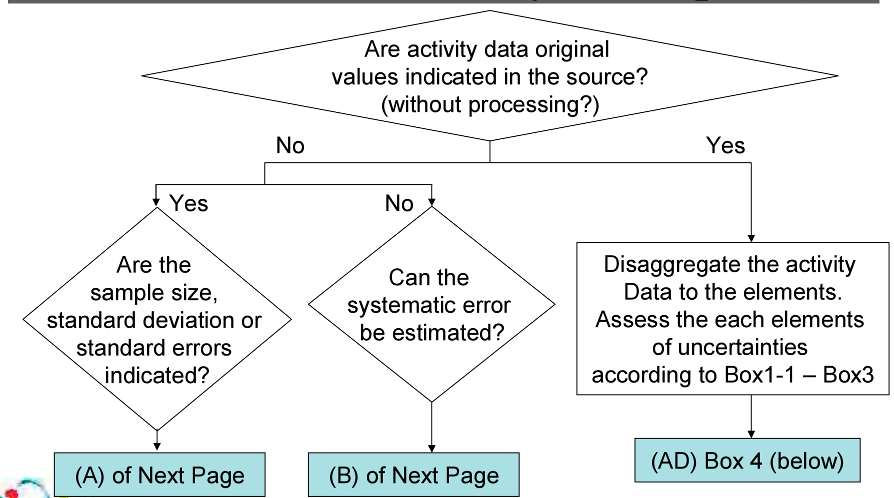
(EF) Box 4 : "When expert judgment is not possible" and "No standard value for uncertainty is provided in GPG"

Category	Uncertainty of EF
1. Energy	
1.A. CO_2	5%
1.A. CH_4, N_2O	3%~10%
1.A.3. Transport(CH_4, N_2O)	5%
2. Industrial Processes	
Excluding HFCs, PFCs, SF_6	1%~100%
HFCs, PFCs, SF_6	5%~50%
3. Solvent and Other Product Use	-*
4. Agriculture	2%~60%
5. Land Use Change and Forestry	-**
6. Waste	5%~100%

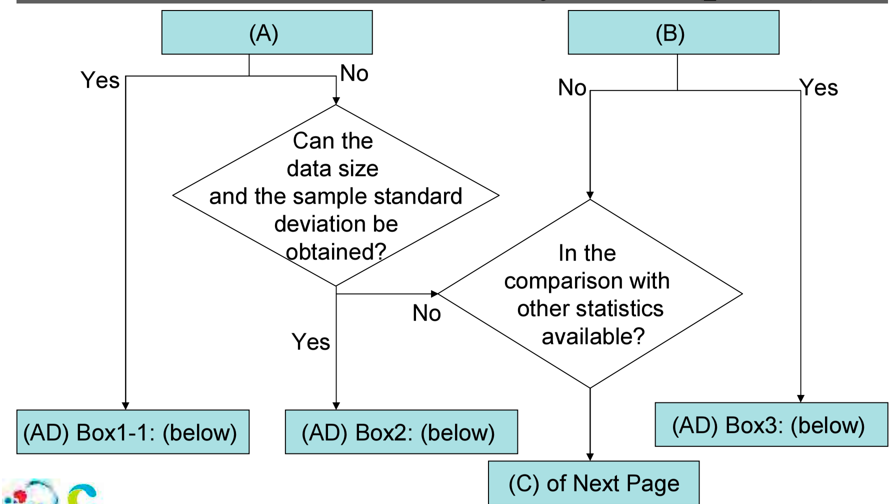
* Category 3: The use of organic solvents and other such products are not dealt within the GPG (2000).
** Category 5: Changes in land use and forestry are not dealt with in the GPG (2000).

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

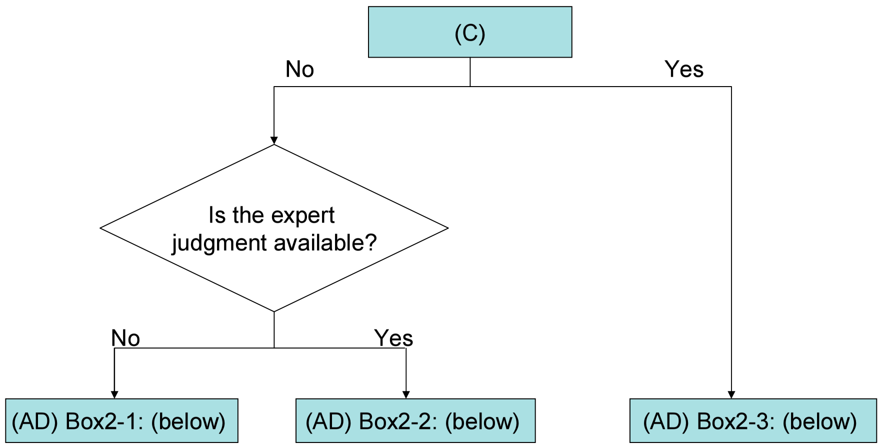
Decision tree for assessing uncertainty associated with Activity Data (part1)



Decision tree for assessing uncertainty associated with Activity Data (part2)



Decision tree for assessing uncertainty associated with Activity Data (part3)



(Activity Data) Box 1-1

- Box 1-1 : "Statistical values based on a sample survey" and "The publisher has made errors public"
  - When the publisher of a statistical document has made the sampling errors public in the sample survey, it should be used as the uncertainty of the activity data.

(Activity Data) Box 1-2

- Box 1-2 : "Statistical values based on a sample survey" and "The publisher has not made errors public"
  - Enquire the publisher of the statistical document for the size of the sample, the sample average, and the standard deviation of the sample.

Uncertainty $U = \left(1.96 \times s / \sqrt{n}\right) / X_{ad}$

X_{ad} : Sample average
S : Standard deviation of sample
n : Number of items of data

If, however, distribution is asymmetrical, the uncertainty U is calculated by dividing the difference between the value of the 95 percent confidence limit furthest from X_{ad} and the average value, by X_{ad}.

(Activity Data) Box 2-1

- "Statistical values based on a sample survey" and "Amount of data and sample standard deviation are not available, and expert judgment is not available"
  - The following standard values should be used

	Fundamental Statistics	Other Statistics
Sample survey	50 %	100 %

(Activity Data) Box 2-2

- Box 2-2 : "Statistical values based on a sample survey" and "Amount of data and sample standard deviation are not available, and expert judgment is available"
  - Ask an expert for the upper and lower limiting values appropriate to activity data in Japan
  - Draw a triangular distribution for activity data with the Japanese activity data as the vertex
  - Upper limiting value is the upper limiting value of 95% confidence interval
  - Lower limiting value is the lower limiting value of 95% confidence interval

(Activity Data) Box 2-3

- Box 2-3 : "Statistical values based on a sample survey" and "Amount of data and sample standard deviation are not available, and crosschecking is possible"
  - In the case of statistics drawn from a sample survey,

Uncertainty $U = (1.96 \times s) / X_{ap}$

X_{ap} : Value used for activity data
s : Standard deviation (data to be cross-checked)

However, if a distribution is asymmetrical, the uncertainty U may be calculated by dividing the difference between the value of the 95 percent confidence limit furthest from X_{ad} and the average value, by X_{ad}.

(Activity Data) Statistical value not based on a sample survey

- "Systemic error can be estimated " : Box 3
- "Systemic error cannot be estimated, and crosschecking is possible" : Box 2-3
- "Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is available" : Box 2-2
- "Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is unavailable" : Box 2-1

(Activity Data) Box 3 (Statistical values not based on a sample survey, etc.)

- "Statistical value not based on a sample survey" and "Systemic error can be estimated" : Box 3
  - Where a systemic error can be estimated, it should be estimated and used. The method by which the systemic error is calculated should be documented, and the document should be retained.

(Activity Data) Box 2-1 (Statistical values not based on a sample survey, etc.)

- "Statistical value not based on a sample survey" and "Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is unavailable" : Box 2-1
  - The following standard values established by the Committee for the GHGs Emissions Estimation Methods should be used.

	Fundamental Statistics	Other Statistics
Survey of total population (no rounding)	5 %	10 %
Survey of total population (rounding)	20 %	40 %

(Activity Data) Box 2-2 (Statistical values not based on a sample survey, etc.)

- "Statistical value not based on a sample survey" and "Systemic error cannot be estimated, crosschecking is not possible, and expert judgment is available" : Box 2-2
  - Same as for "Amount of data and sample standard deviation are not available, and expert judgment is available" of "Statistical values based on a sample survey" (Box 2-2).

(Activity Data) Box 2-3 (Statistical values not based on a sample survey, etc.)

- "Statistical value not based on a sample survey" and "Systemic error cannot be estimated, and crosschecking is available" : Box 2-3
  - When systemic error cannot be estimated, but it is possible to compare the relevant statistical value with other statistical values, uncertainty should be assessed using the same means in Case 2 described at A1.2.3 of Section A1.7 of the Good Practice Guidance (2000).

(Activity Data) Box4 (Using statistical values processed as activity data)

- Using statistical values processed as activity data (not original values in the source).
- a) Breakdown of each element of activity data and assessment
- b) Combining elements
  - Activity data is express as A1 + A2

$$U_{A\text{-total}} = \frac{\sqrt{(U_{A1} \times A_1)^2 + (U_{A2} \times A_2)^2}}{A_1 + A_2}$$

  - Activity data is express as A1 x A2

$$U_A = \sqrt{U_{A1}^{\ 2} + U_{A2}^{\ 2}}$$

Uncertainty of Japan's Total Net Emissions

IPCC Category	GHGs	Emissions / Removals [Gg CO_2 eq.] A	[%]	Combined Uncertainty [%] [1] B	rank	Combined uncertainty as % of total national emissions C	rank
1A. Fuel Combustion (CO_2)	CO_2	1,151,985.3	89.9%	1%	10	0.76%	2
1A. Fuel Combustion (Stationary:CH_4,N_2O)	CH_4、N_2O	5,060.9	0.4%	27%	3	0.11%	8
1A. Fuel Combustion (Transport:CH_4,N_2O)	CH_4、N_2O	2,962.5	0.2%	355%	1	0.87%	1
1B. Fugitive Emissions from Fuels	CO_2、CH_4、N_2O	446.4	0.0%	19%	5	0.01%	9
2. Industrial Processes (CO_2,CH_4,N_2O)	CO_2、CH_4、N_2O	51,667.6	4.0%	7%	7	0.32%	7
2. Industrial Processes (HFCs,PFCs,SF_6)	HFCs、PFCs、SF_6	23,642.7	1.8%	26%	4	0.52%	4
3. Solvent & other Product Use	N_2O	160.4	0.0%	5%	9	0.00%	10
4. Agriculture	CH_4、N_2O	25,844.9	2.0%	18%	6	0.38%	6
5. LULUCF	CO_2、CH_4、N_2O	-78,807.9	-6.1%	6%	8	0.42%	5
6. Waste	CO_2、CH_4、N_2O	20,058.0	1.6%	32%	2	0.53%	3
Total Net Emissions	(D)	1,203,020.6		(E) [2] 2%			

1) $C = A \times B / D$

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

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Consideration of the results

- The result of uncertainty assessment shows that Japan's uncertainty of total net emissions is approximately 2%.
- This value is relatively smaller compared to 21.3% of UK indicated in the GPG(2000).
  - The ratio of Japan's N2O emission from "Agricultural Soils (Direct Soil Emissions)" is small compared to that of UK (in 2003; Japan-0.28%, UK-4.1%)
- Example of Uncertainty analysis for Finland in 2005 is shown in "2006 IPCC Guidelines". These trends are similar to this example of the UK.

Issue in Uncertainty Assessment in Japan (part1)

- Only emission sources of which emissions had already been calculated were the subject of uncertainty assessment. No assessment has been made for emission sources such as "NE" and "PART".
- Therefore, the uncertainty of total emissions prepared by compiling the uncertainty of emissions does not depict the uncertainty of inventory in context of the realities of emissions.

Issue in Uncertainty Assessment in Japan (part2)

- The number of decimal places to be used when depicting uncertainty was set as follows;
  - Uncertainty of EF is given to one decimal place.
  - Uncertainty of AD is also given one decimal place.
  - Uncertainty of emissions is given as an integer.
- As the precision of uncertainty assessment varies between emission sources, further consideration needs to be given to the number of decimal place that are effective in uncertainty assessment.

3. Key Categories

- 3-1 What is the "Key Category"?
- 3-2 The Method of Key Category Analysis

3-1 What is the "Key Categories"?

- A "Key Category" is one that is prioritised within the national inventory system because its estimate has a significant influence on a country's total inventory of greenhouse gas in terms of the absolute level, the trend, or the uncertainty in emissions and removals. Whenever the term key category is used, it includes both source and sink categories.

Introduction of "Key Categories" 1

- Methodological choice for individual source and sink categories is important in managing overall inventory uncertainty.
- By identifying these key categories in the national inventory, inventory compilers can prioritise their efforts and improve their overall estimates.

Introduction of "Key Categories" 2

- It is good practice for each country to identify its national key categories in a systematic and objective manner.
- Consequently, it is good practice to use results of key category analysis as a basis for methodological choice.

Overview of the Key Category Analysis

- Purpose of "Key Category analysis "
  - (Firstly); Identification of key categories enables limited resources available for preparing inventories to be prioritised.
  - (Secondly); In general, more detailed higher tier methods should be selected for key categories.
  - (Thirdly); It is good practice to give additional attention to key categories with respect to QA/QC.
- The key category analysis is to figure out the important sub-sectors of GHG inventory using the amount of emission, uncertainty and these of time-series.

3-2 The Method of Key Category Analysis

- A "Key Category" is prioritized within the national inventory system
  - (Estimate) The absolute Level (Level Assessment)
  - (Estimate) The Trend (Trend Assessment)
  - (Estimate) The Uncertainty (Both Level and Trend)
- Approach 1 : Level Assessment and Trend Assessment (Sources and Sinks)
- Approach 2 : Level Assessment / Trend Assessment and Based on the results of the "Uncertainty" (Sources and Sinks)

Estimation Methods for Key Category Analysis

	Level Assessment	Trend Assessment
Approach 1	Sources and Sinks Only Level 95% add up	Source and Sinks Significantly different from the trend 95% add up
Approach 2	Sources and Sinks (based on the uncertainty analysis) Only Level 90% add up	Sources and Sinks (based on the uncertainty analysis) Significantly different from the trend 90% add up

Approach 1: Level Assessment

- LEVEL ASSESSMENT
  - Key category level assessment = |source or sink category estimate| / total contribution

$$L_{x,t} = \left|E_{x,t}\right| \Big/ \sum_y \left|E_{y,t}\right|$$

- $L_{x,t}$ = level assessment for source or sink x in latest inventory year (year t)
- $\left|E_{x,t}\right|$ = absolute value of emission or removal estimate of source or sink category x in year t
- $\sum_y \left|E_{y,t}\right|$ = total contribution, which is the sum of the absolute values of emissions and removals in year t
  - The key categories are those that add up to 95 % of the sum of all $U_{x,t}$.

Approach 1: Trend Assessment

- TRENDASSESSMENT

$$T_{x,t} = \frac{|E_{x,0}|}{\sum_y |E_{y,0}|} \bullet \left| \left[\frac{(E_{x,t} - E_{x,0})}{|E_{x,0}|} \right] - \frac{\left(\sum_y E_{y,t} - \sum_y E_{y,0}\right)}{\left|\sum_y E_{y,0}\right|} \right|$$

  - $T_{x,t}$ = trend assessment of source or sink category x in year t as compared to the base year (year 0)
  - $|E_{x,0}|$ = absolute value of emission or removal estimate of source or sink category x in year 0
  - $E_{x,t}$ and $E_{x,0}$ = real value of estimate of source or sink category x in year t and 0, respectively
  - $\sum E_{y,t}$ and $\sum E_{y,0}$ = total inventory estimates in year t and 0, respectively
  - The key categories are those that add up to 95 % of the sum of all $T_{x,t}$.

Approach 2: Level Assessment and Trend Assessment

- Level Assessment

$$LU_{x,t} = |L_{x,t} \bullet U_{x,t}| \Big/ \sum_y [(L_{y,t} \bullet U_{y,t})]$$

  - The key categories are those that add up to 90 % of the sum of all $LU_{x,t}$.
- Trend Assessment

$$TU_{x,t} = (T_{x,t} \bullet U_{x,t})$$

  - The key categories are those that add up to 90 % of the sum of all $TU_{x,t}$.

4 Case Study of "Key Categories" (Japan's cases)

- Level Assessment
  - Calculating the proportion of emissions and removals in each category to the total emissions and removals
  - The calculated values of proportion are added from the category that accounts for the largest proportion, until the sum reaches 95% for "Approach 1", 90% for "Approach 2".
  - "Approach 1" level assessment use emissions and removals from each category directly and "Approach 2" level assessment analyzes the emissions and removals of each category, multiplied by the uncertainty of each category.

Key category analysis (Level Assessment in Japan)

- [key category analysis]
  - First (1) : Estimate excluding LULUCF
  - Second (2) : Estimate including LULUCF

  - In accordance with the GPG-LULUCF,
  - Patern1 : A source category, which was identified as key in (1) but not in (2), was still regarded as key.
  - Patern2 : A source category, which was not identified as key in (1) but was done in (2), was not regarded as key.

Results of Approach 1 Level Assessment (FY2008)

	A IPCC Category		B Direct GHGs	C Base Year Estimate [Gg CO2 eq.]	D Current Year Estimate [Gg CO2 eq.]	E Level Assessment	F % Contribution to Level	Cumulative
#1	1A Stationary Combustion	Solid Fuels	CO_2	398,620.23	451,548.45	0.310	31.0%	31.0%
#2	1A Stationary Combustion	Liquid Fuels	CO_2	485,168.99	325,918.28	0.224	22.4%	53.4%
#3	1A3 Mobile Combustion	b. Road Transportation	CO_2	189,227.88	214,087.49	0.147	14.7%	68.1%
#4	1A Stationary Combustion	Gaseous Fuels	CO_2	104,310.83	203,273.46	0.140	14.0%	82.1%
#5	5A Forest Land	1. Forest Land remaining Forest Land	CO_2	72,020.59	82,803.92	0.057	5.7%	87.8%
#6	2A Mineral Product	1. Cement Production	CO_2	37,966.28	30,076.22	0.021	2.1%	89.8%
#7	1A Stationary Combustion	Other Fuels	CO_2	9,102.41	14,407.93	0.010	1.0%	90.8%
#8	6C Waste Incineration		CO_2	12,262.95	13,448.88	0.009	0.9%	91.7%
#9	1A3 Mobile Combustion	d. Navigation	CO_2	13,720.95	12,169.96	0.008	0.8%	92.6%
#10	2A Mineral Product	3. Limestone and Dolomite Use	CO_2	11,527.41	12,013.50	0.008	0.8%	93.4%
#11	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	840.42	11,438.28	0.008	0.8%	94.2%
#12	1A3 Mobile Combustion	a. Civil Aviation	CO_2	7,162.41	10,875.77	0.007	0.7%	94.9%
#13	2A Mineral Product	2. Lime Production	CO_2	7,321.64	7,758.21	0.005	0.5%	95.5%

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Results of Approach 2 Level Assessment (FY2008)

	A IPCC Category		B Direct GHGs	D Current Year Estimate [Gg CO2 eq.]	I Source/Sink Uncertainty	K Contribution to Total L2	Cumulative
#1	1A3 Mobile Combustion	a. Civil Aviation	N_2O	103.18	1000%	14.4%	14.4%
#2	1A Stationary Combustion	Solid Fuels	CO_2	420,523.44	2%	8.9%	23.3%
#3	2F(a) Consumption of Halocarbons	1. Refrigeration and Air Conditioning	HFCs	13,230.09	43%	8.0%	31.3%
#4	5A Forest Land	1. Forest Land remaining Forest Land	CO_2	79,869.29	6%	7.0%	38.3%
#5	1A3 Mobile Combustion	b. Road Transportation	CO_2	205,416.98	2%	6.6%	44.9%
#6	1A Stationary Combustion	Other Fuels	CO_2	13,812.17	29%	5.6%	50.5%
#7	2A Mineral Product	1. Cement Production	CO_2	27,996.35	10%	4.1%	54.6%
#8	1A Stationary Combustion	Liquid Fuels	CO_2	290,150.45	1%	4.0%	58.5%
#9	4D Agricultural Soils	1. Direct Soil Emissions	N_2O	3,112.07	90%	3.9%	62.4%
#10	4B Manure Management		N_2O	4,767.61	48%	3.2%	65.6%
#11	2A Mineral Product	3. Limestone and Dolomite Use	CO_2	12,148.48	17%	2.8%	68.5%
#12	4D Agricultural Soils	3. Indirect Emissions	N_2O	2,924.89	63%	2.6%	71.1%
#13	2F(a) Consumption of Halocarbons	7. Semiconductor Manufacture	PFCs	2,756.49	64%	2.5%	73.5%
#14	1A3 Mobile Combustion	b. Road Transportation	N_2O	2,494.53	71%	2.5%	76.0%
#15	4B Manure Management		CH_4	2,327.53	64%	2.1%	78.1%
#16	1A Stationary Combustion		N_2O	4,054.81	33%	1.9%	79.9%
#17	4C Rice Cultivation		CH_4	5,615.73	23%	1.9%	81.8%
#18	2E Production of Halocarbons	2. Fugitive Emissions	SF_6	1,238.21	100%	1.8%	83.6%
#19	2A Mineral Product	2. Lime Production	CO_2	6,931.21	16%	1.5%	85.1%
#20	1A3 Mobile Combustion	d. Navigation	N_2O	95.95	1000%	1.3%	86.4%
#21	6D Other		CO_2	530.41	159%	1.2%	87.6%
#22	4A Enteric Fermentation		CH_4	6,944.81	12%	1.1%	88.7%
#23	2F(a) Consumption of Halocarbons	7. Semiconductor Manufacture	SF_6	952.48	64%	0.9%	89.6%
#24	1A Stationary Combustion	Gaseous Fuels	CO_2	199,519.14	0%	0.8%	90.4%

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Key category analysis (Trend Assessment in Japan) part1

- Step 1: The difference between the rate of change in emissions and removals in a category
- Step 2: The rate of change in total emissions and removals
- Step 3: Multiplying this value by the ration of contribution of the relevant category to total emissions and removals

Key category analysis (Trend Assessment in Japan) part2

- Trend Assessment
  - Until the sum reaches 95% for Approach 1 (emissions and removals from each category directly)
  - Until the sum reaches 90% for Approach 2 (emissions and removals of each category multiplied by the uncertainty of each category)
  - First (1) : Estimate excluding LULUCF
  - Second (2) : Estimate including LULUCF
  - In accordance with the GPG-LULUCF,
  - Patern1 : A source category, which was identified as key in (1) but not in (2), was still regarded as key.
  - Patern2 : A source category, which was not identified as key in (1) but was done in (2), was not regarded as key.
  - (note: same as "Level Assessment")

Results of Approach 1 Trend Assessment (FY2008)

	A IPCC Category		B Direct GHGs	C Base Year Estimate [Gg CO2 eq.]	D Current Year Estimate [Gg CO2 eq.]	H % Contribution to Trend	Cumulative
#1	1A Stationary Combustion	Liquid Fuels	CO2	435169	325918	30.1%	30.1%
#2	1A Stationary Combustion	Solid Fuels	CO2	308620	451548	24.1%	54.2%
#3	1A Stationary Combustion	Gaseous Fuels	CO2	104301	203273	18.6%	72.8%
#4	2E Production of Halocarbons and SF6	1. By-product Emissions (Production of HCFC-22)	HFCs	16965	218	3.7%	76.5%
#5	2A Mineral Product	1. Cement Production	CO2	37966	30076	2.3%	78.8%
#6	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	8. Electrical Equipment	SF6	11005	922	2.3%	81.1%
#7	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	1. Refrigeration and Air Conditioning Equipment	HFCs	840	11438	2.2%	83.3%
#8	2F(a) Consumption of Halocarbons and SF6 (actual emissions - Tier 2)	5. Solvents	PFCs	10264	1927	1.9%	85.2%
#9	1A3 Mobile Combustion	b. Road Transportation	CO2	189228	214087	1.8%	87.0%
#10	2B Chemical Industry	3. Adipic Acid	N2O	7501	271	1.6%	88.6%
#11	5E Settlements	2. Land converted to Settlements	CO2	5362	995	1.0%	89.6%
#12	5A Forest Land	1. Forest Land remaining Forest Land	CO2	72021	82804	1.0%	90.6%
#13	1A Stationary Combustion	Other Fuels	CO2	9102	14408	0.9%	91.5%
#14	6A Solid Waste Disposal on Land		CH4	7528	3909	0.9%	92.4%
#15	2E Production of Halocarbons and SF6	2. Fugitive Emissions	SF6	4708	1199	0.8%	93.2%
#16	1A3 Mobile Combustion	a. Civil Aviation	CO2	7162	10876	0.6%	93.9%
#17	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	2785	40	0.6%	94.5%
#18	1A3 Mobile Combustion	d. Navigation	CO2	13731	12170	0.6%	95.1%

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Results of Approach 2 Trend Assessment (FY2008)

	A IPCC Category		B Direct GHGs	C Base Year Estimate [Gg CO2 eq.]	D Current Year Estimate [Gg CO2 eq.]	I Source/Sink Uncertainty	M Contribution to Total T2	Cumulative
#1	2F(a) Consumption of Halocarbons	1. Refrigeration and Air Conditioning	HFCs	840.40	13,236.09	43%	13.0%	13.0%
#2	2F(a) Consumption of Halocarbons	8. Electrical Equipment	SF6	11,004.99	868.06	40%	10.2%	23.2%
#3	2F(a) Consumption of Halocarbons	5. Solvents	PFCs	10,263.55	1,318.27	40%	8.9%	32.1%
#4	2E Production of Halocarbons	2. Fugitive Emissions	SF6	4,703.30	1,268.21	100%	8.6%	40.7%
#5	1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	103.13	10000%	7.9%	48.5%
#6	1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	2,785.23	32.57	114%	7.8%	56.3%
#7	1A Stationary Combustion	Solid Fuels	CO2	308,621.22	420,523.41	2%	3.9%	60.2%
#8	1A Stationary Combustion	Liquid Fuels	CO2	435,168.99	290,150.45	1%	3.6%	63.9%
#9	1A Stationary Combustion	Other Fuels	CO2	9,102.41	13,812.17	29%	3.2%	67.1%
#10	2A Mineral Product	1. Cement Production	CO2	37,965.28	27,996.35	10%	2.7%	69.8%
#11	1A3 Mobile Combustion	b. Road Transportation	N2O	3,901.71	2,494.53	71%	2.5%	72.3%
#12	4D Agricultural Soils	1. Direct Soil Emissions	N2O	4,098.51	3,112.07	50%	2.3%	74.7%
#13	2E Production of Halocarbons	1. By-product Emissions	HFCs	16,965.00	469.17	5%	2.2%	76.9%
#14	1A Stationary Combustion		N2O	2,053.31	4,054.81	33%	1.6%	78.5%
#15	2B Chemical Industry	3. Adipic Acid	N2O	7,501.25	739.45	9%	1.5%	80.0%
#16	5B Cropland	2. Land converted to Cropland	CO2	2,573.15	223.33	25%	1.5%	[illegible]
#17	4D Agricultural Soils	3. Indirect Emissions	N2O	3,732.52	2,924.89	63%	1.3%	82.8%
#18	4B Manure Management		CH4	3,094.12	2,327.53	64%	1.3%	[illegible]
#19	4B Manure Management		N2O	5,533.01	4,767.61	48%	1.0%	85.1%
#20	5A Forest Land	1. Forest Land remaining Forest Land	CO2	72,020.59	79,869.29	6%	1.0%	86.1%
#21	5E Settlements	2. Land converted to Settlements	CO2	5,352.15	1,601.42	9%	0.9%	87.0%
#22	4C Rice Cultivation		CH4	6,955.68	5,613.73	23%	0.8%	87.8%
#23	5F Other Land	2. Land converted to Other Land	CO2	1,585.53	387.51	28%	0.8%	88.7%
#24	2B Chemical Industry	1. Ammonia Production	CO2	3,384.58	1,989.83	23%	0.8%	89.5%
#25	5A Forest Land	2. Land converted to Forest Land	CO2	406.31	65.00	91%	0.8%	90.2%

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

The Sample of Data used for the key category analysis (FY2008)

A IPCC Category		B Direct GHGs	C Base Year Estimate	D Current Year Estimate	E Level Assessment	F % Contribution to Level	G Trend Assessment	H % Contribution to Trend	I Source/Sink Uncertainty	J Level Uncertainty	K Contribution to Total L2	L Trend Uncertainty	N Contribution to Total T2
1A Stationary Combustion	Liquid Fuels	CO2	435,168.99	290,150.45	0.212	21.7%	[illegible]	[illegible]	1%	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion	Solid Fuels	CO2	308,621.22	420,523.41	0.306	30.3%	[illegible]	[illegible]	2%	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion	Gaseous Fuels	CO2	[illegible]	[illegible]	0.146	14.6%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion	Other Fuels	CO2	9,102.41	13,812.17	0.010	1.0%	[illegible]	[illegible]	29%	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion		CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion		N2O	2,053.31	4,054.81	[illegible]	[illegible]	[illegible]	[illegible]	33%	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion		CH4	49.20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	115%	[illegible]	[illegible]	[illegible]	[illegible]
1A Stationary Combustion		N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	a. Civil Aviation	CO2	7,162.41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	b. Road Transportation	CO2	189,227.88	[illegible]	0.150	15.0%	[illegible]	[illegible]	2%	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	c. Railways	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	d. Navigation	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	a. Civil Aviation	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200%	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	b. Road Transportation	CH4	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	64%	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	c. Railways	CH4	1.18	[illegible]	0.000	[illegible]	[illegible]	[illegible]	14%	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	d. Navigation	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	a. Civil Aviation	N2O	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	10000%	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	b. Road Transportation	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	c. Railways	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1A3 Mobile Combustion	d. Navigation	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	114%	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	1a ii. Coal Mining and Handling (surface)	CH4	21.20	[illegible]	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2a. Oil	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2a. Oil	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2a. Oil	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2b. Natural Gas	CO2	0.25	[illegible]	0.000	[illegible]	[illegible]	[illegible]	25%	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2b. Natural Gas	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2c. Venting & Flaring	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2c. Venting & Flaring	CH4	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1B Fugitive Emission	2c. Venting & Flaring	N2O	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2A Mineral Product	1. Cement Production	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2A Mineral Product	2. Lime Production	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2A Mineral Product	3. Limestone and Dolomite Use	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2A Mineral Product	4. Soda Ash Production and Use	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	1. Ammonia Production	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	other products except Ammonia	CO2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	2. Nitric Acid	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	3. Adipic Acid	N2O	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2B Chemical Industry	5. Carbon Black, Ethylene, Ethylene Dichloride, Styrene, Methanol, Coke	CH4	[illegible]	[illegible]	0.000	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2C Metal Production	1. Iron and Steel Production	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2C Metal Production	1. Iron and Steel Production	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2C Metal Production	2. Ferroalloys Production	CH4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

The Sample of Data used for the key category analysis (FY1990)

A IPCC Category		B Direct GHGs	C Base Year Estimate [Gg CO2 eq.]	E Level Assessment	F % Contribution to Level	I Source/Sink Uncertainty	J Level Uncertainty (x 100%)	K Contribution to Total L2
1A Stationary Combustion	Liquid Fuels	CO2	435,168.99	0.324	32.4%	1%	3.16	0.05
1A Stationary Combustion	Solid Fuels	CO2	308,620.23	0.230	23.0%	2%	5.50	0.06
1A Stationary Combustion	Gaseous Fuels	CO2	[illegible]	0.078	7.8%	3%	0.23	0.00
1A Stationary Combustion	Other Fuels	CO2	9,102.41	0.007	0.7%	29%	1.56	0.03
1A Stationary Combustion		CH4	573.48	0.000	0.0%	47%	0.19	0.00
1A Stationary Combustion		N2O	2,053.31	0.002	0.2%	33%	0.50	0.01
1A Stationary Combustion		CH4	49.20	0.000	0.0%	115%	0.04	0.00
1A Stationary Combustion		N2O	185.38	0.000	0.0%	47%	0.11	0.00
1A3 Mobile Combustion	a. Civil Aviation	CO2	7,162.41	0.005	0.5%	3%	0.13	0.00
1A3 Mobile Combustion	b. Road Transportation	CO2	189,227.88	0.141	14.1%	2%	3.24	0.05
1A3 Mobile Combustion	c. Railways	CO2	932.45	0.001	0.1%	2%	0.02	0.00
1A3 Mobile Combustion	d. Navigation	CO2	13,730.95	0.010	1.0%	2%	0.74	0.00
1A3 Mobile Combustion	a. Civil Aviation	CH4	2.94	0.000	0.0%	200%	0.00	0.00
1A3 Mobile Combustion	b. Road Transportation	CH4	366.66	0.000	0.0%	64%	0.13	0.00
1A3 Mobile Combustion	c. Railways	CH4	1.18	0.000	0.0%	14%	0.00	0.00
1A3 Mobile Combustion	d. Navigation	CH4	26.45	0.000	0.0%	200%	0.04	0.00
1A3 Mobile Combustion	a. Civil Aviation	N2O	69.75	0.000	0.0%	10000%	5.20	0.08
1A3 Mobile Combustion	b. Road Transportation	N2O	3,901.71	0.003	0.3%	71%	2.06	0.03
1A3 Mobile Combustion	c. Railways	N2O	121.36	0.000	0.0%	1%	0.01	0.00
1A3 Mobile Combustion	d. Navigation	N2O	111.58	0.000	0.0%	1000%	0.83	0.01
1B Fugitive Emission	1a i. Coal Mining and Handling (under gr.)	CH4	2,785.23	0.002	0.2%	114%	2.36	0.04
1B Fugitive Emission	1a ii. Coal Mining and Handling (surface)	CH4	21.20	0.000	0.0%	185%	0.03	0.00
1B Fugitive Emission	2a. Oil	CO2	0.14	0.000	0.0%	[illegible]	0.00	0.00
1B Fugitive Emission	2a. Oil	CH4	28.32	0.000	0.0%	17%	0.00	0.00
1B Fugitive Emission	2a. Oil	N2O	0.00	0.000	0.0%	27%	0.00	0.00
1B Fugitive Emission	2b. Natural Gas	CO2	0.25	0.000	0.0%	25%	0.00	0.00
1B Fugitive Emission	2b. Natural Gas	CH4	187.94	0.000	0.0%	71%	0.07	0.00
1B Fugitive Emission	2c. Venting & Flaring	CO2	36.23	0.000	0.0%	18%	0.00	0.00

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Japan's Key Source Categories in 1990

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

N.B. Figures recorded in the column L (Level) indicate the ranking of level assessment.
The data of HFCs, PFCs and SF6 utilized for the analysis are the 1995 values.

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Japan's Key Source Categories in 2008

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

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

Source: National Greenhouse Gas Inventory Report of JAPAN (April 2010)

Example of "Key Category Ranking"

- EMEP/EEA air pollutant emission inventory guidebook 2009
- 2. key category analysis and methodological choice
- Table A-2 Final category ranking across all pollutants considered in analysis.

Example of "Key Category Ranking"

Sector code	Sector Description	% contributions to pollutant totals for key categories (cumulative 80 %)							Sum of KC % contributions	Rank
		CO	NH_3	NMVOC	NO_x	PM_{10}	$PM_{2.5}$	SO_x		
1.A.1.a	Public electricity and heat production				[illegible]	6	5	60	97	1
1.A.2.f	Other manufacturing industries and construction	4		[illegible]	15	17	5	[illegible]	[illegible]	[illegible]
1.A.3.b.i	Road transport: passenger cars	40		7	13	[illegible]	7		73	3
1.A.4.b.i	Residential plants	25		4	7	17	15		[illegible]	4
1.A.3.b.iii	Road transport: heavy-duty vehicles			2	13	5	7		32	5
4.B.1.a	Dairy		25						25	6
4.B.1.b	Non-dairy		23						23	7
3.D	Other solvent and other product use (including products containing HMs (heavy metals) and POPs)			22					22	8
1.A.3.b.ii	Road transport: light duty vehicles					7	11		18	9

Source; Table A-2 of "EMEP/EEA emission inventory guidebook 2009"

Key Category Ranking (presenter's opinion)

- I think that it is good practice that the level assessment and trend assessment of each category are simply summed up and the priorities of key category are decided from these results.
- I think that in Thailand it is not bad that key category ranking is decided in preference to the level of assessment. (present)

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

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

INV09 and INV10
Review and Practice of Greenhouse Gas Inventory

February, 2011

GHG Inventory
Fumihiko KUWAHARA

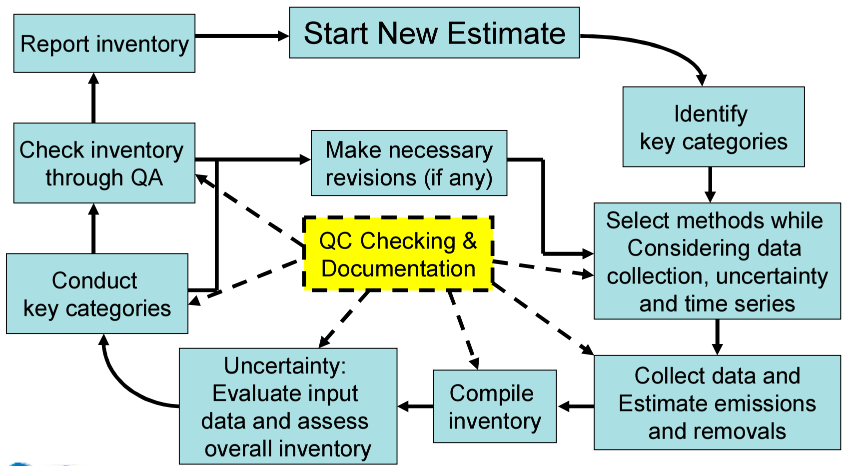
Contents

Components of Inventory Work

- Data Collection and Methodological Choice
- Uncertainty Assessment
  - Important for developing mitigation policies & monitoring their impacts
- Identification of Key Categories
- Quality Assurance and Quality Control
- Verification
- Ensuring time series consistency
  - Recalculations
  - Reconstruction of missing data

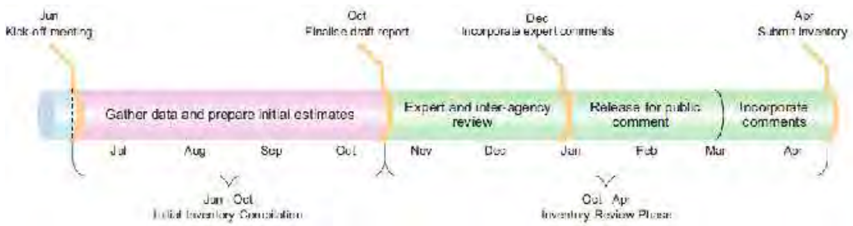
Source: Kiyoto Tanabe's Presentation Material (12 July 2010, Thailand)

Inventory Development Cycle



Example of Inventory Development Cycle

- In a **mature** inventory system, 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-

Practice1: Data Collection

- 1-1 Japan's Case (current situation; from Japanese expert)
- 1-2 Thailand's Case (future vision; from TGO staffs)

Collection process of activity data in Japan

- 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.

Major data or statistics and data providers in Japan (1)

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

Major data or statistics and data providers in Japan (2)

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

Major data or statistics and data providers in Japan (3)

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

1-2 Thailand's Case of Data Collection (Please talk TGO Staff's Opinions)

- Please introduce Thailand's Future Plan (Vision) of Data Collection. (from GHG Information Center Staffs)
- Mr. Tony-san (Mr. Chetsada)
- Ms. Note-san (Ms. Wasinee)
- Ms. B-san (Ms. Wararat)
- Ms. May-san (Ms. Mewadee)

1-2 Thailand's Case of Data Collection (JICA Expert's Comments)

- Not Published Data / Data Incompatibility / Missing Data etc.
  - The development of new methods of data collection (private sector's data, academic data, etc.)
  - Consideration of the Surrogate Data and adapting data
  - Please refer "IPCC Guidelines" and "National Greenhouse Gas Inventory Report of Annex I countries"

Practice2: Uncertainty Analysis

- Review of Basic Methods of Uncertainty Analysis
- Introduction of Example of Uncertainty Estimation in "2006 IPCC Guidelines"

Review: Basic Equation of "Uncertainties"

- Multiplication: A1 x A2 (e.g. combine EF AD parameter)

$$U_A = \sqrt{U_{A1}{}^2 + U_{A2}{}^2}$$

- Addition and Subtraction: A1 + A2 (e.g. overall uncertainty in national inventory)

$$U_{A\text{-total}} = \frac{\sqrt{(U_{A1} \times A_1)^2 + (U_{A2} \times A_2)^2}}{A_1 + A_2}$$

Review: Example of Emission Factor Uncertainties (from 2006 IPCC Guidelines)

TABLE 2.2
DEFAULT EMISSION FACTORS FOR STATIONARY COMBUSTION IN THE ENERGY INDUSTRIES
(kg of greenhouse gas per TJ on a Net Calorific Basis)

Fuel		CO2			CH4			N2O		
		Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper	Default Emission Factor	Lower	Upper
Crude Oil		73 300	71 100	75 500	r 3	1	10	0.6	0.2	2
Orimulsion		r 77 000	69 300	85 400	r 3	1	10	0.6	0.2	2
Natural Gas Liquids		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2	2
Gasoline	Motor Gasoline	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2	2
	Aviation Gasoline	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2	2
	Jet Gasoline	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.2	2
Jet Kerosene		r 71 500	69 700	74 400	r 3	1	10	0.6	0.2	2
Other Kerosene		71 900	70 800	73 700	r 3	1	10	0.6	0.2	2
Shale Oil		73 300	67 800	79 200	r 3	1	10	0.6	0.2	2
Gas/Diesel Oil		74 100	72 600	74 800	r 3	1	10	0.6	0.2	2

$$\frac{75500 - 73300}{73300} \approx +3\%, \quad \frac{71100 - 73300}{73300} \approx -3\%$$

Source: 2006 IPCC Guidelines Volume 2: Energy

Review: Example of Activity Data Uncertainties

TABLE 2.15
LEVEL OF UNCERTAINTY ASSOCIATED WITH STATIONARY COMBUSTION ACTIVITY DATA

Sector	Well developed statistical systems		Less developed statistical systems	
	Surveys	Extrapolation	Surveys	Extrapolation
Main activity electricity and heat production	Less than 1%	3-5%	1-2%	5-10%
Commercial, institutional, residential combustion	3-5%	5-10%	10-15%	15-25%
Industrial combustion (Energy intensive industries)	2-3%	3-5%	2-3%	5-10%
Industrial combustion (others)	3-5%	5-10%	10-15%	15-20%
Biomass in small sources	10-30%	20-40%	30-60%	60-100%

The inventory compiler should judge which type of statistical system best describes their national circumstances.
Source: IPCC *Good Practice Guidance* and Uncertainty Management in National Greenhouse Gas Inventories (2000)

Source: 2006 IPCC Guidelines Volume 2: Energy

Review: Example of Combined Uncertainty

	Emissions (Gg CO2/year)	Activity Data Uncertainty (%)	EF Uncertainty (%)	Combined Uncertainty (%)	Contribution to Variance by Category
Source 1	E1	U_{A1}	U_{EF1}	$CU1 = \sqrt{U_{A1}^2 + U_{EF1}^2}$	$CV1 = \frac{(CU1 \times E1)^2}{(E1+E2+E3)^2}$
Source 2	E2	U_{A2}	U_{EF2}	$CU2 = \sqrt{U_{A2}^2 + U_{EF2}^2}$	$CV2 = \frac{(CU2 \times E2)^2}{(E1+E2+E3)^2}$
Source 3	E3	U_{A3}	U_{EF3}	$UC3 = \sqrt{U_{A3}^2 + U_{EF3}^2}$	$CV3 = \frac{(CU3 \times E3)^2}{(E1+E2+E3)^2}$
Total	E1+E2+E3				$\sqrt{CV1+CV2+CV3}$

Percentage uncertainty in total Inventory

Example of Default Uncertainty Values (Cement Production: IPPU Sector)

TABLE 2.3
DEFAULT UNCERTAINTY VALUES FOR CEMENT PRODUCTION

Uncertainty[a]	Comment	Tier
Chemical Analysis/Composition		
2-7%	Assumption of 95% clinker factor in portland cement	1
1-2%	Chemical analysis of clinker to determine CaO	2
3-8%	Assumption of 65% CaO in clinker	2
1-3%	Assumption that 100% CaO is from $CaCO_3$ (uncertainty is higher if ash or slag feeds are used but not accounted for)	2
1%	Assumption of 100% calcination of carbonate destined to become clinker	2, 3
1-3%	Kerogen (or other non-carbonate carbon) determination	3
1-3%	Overall chemical analysis pertaining to carbonate content (mass) & type	3
1-5%	Assumption that the carbonate species is 100% $CaCO_3$	3
Production Data		
1-3%	Reported (plant-level) cement production data	1
35%	Assumption that country output is 100% portland cement	1

Source: 2006 IPCC Guidelines Volume 3: IPPU

Example of Default Uncertainty Values (Rice Cultivation: AFOLU Sector)

TABLE 5.12
DEFAULT CH_4 EMISSION SCALING FACTORS FOR WATER REGIMES DURING THE CULTIVATION PERIOD RELATIVE TO CONTINUOUSLY FLOODED FIELDS

Water regime		Aggregated case: Scaling factor (SF_w)	Aggregated case: Error range	Disaggregated case: Scaling factor (SF_w)	Disaggregated case: Error range
Upland[a]		0	-	0	-
Irrigated[b]	Continuously flooded			1	0.79 - 1.26
	Intermittently flooded – single aeration	0.78	0.62 - 0.98	0.60	0.46 - 0.80
	Intermittently flooded – multiple aeration			0.52	0.41 - 0.66
Rain-fed and deep water[c]	R[illegible]				
	I[illegible]				

ND: not determined

$$\frac{0.98-0.78}{0.78} \approx +25.6\%, \frac{0.62-0.78}{0.78} \approx -20.5\%$$

Source: 2006 IPCC Guidelines Volume 4: AFOLU

Example of Default Uncertainty Values of Parameter (Waste Sector)

3.7.2.2 UNCERTAINTIES ASSOCIATED WITH PARAMETERS

Methane correction factor (MCF)
There are two sources of uncertainty in the MCF

- Uncertainty in the value of the MCF for each type of site (managed-anaerobic, managed-semi-aerobic, unmanaged deep and/or high water table, unmanaged shallow). These MCF values are based on one experimental study and expert judgement and not on measured data.
- Uncertainty in the classification of sites into the different site types. For example, the distinction between deep and shallow sites (5 m depth of waste) is based on expert opinion. Inevitably, few, if any, countries will be able to classify their unmanaged waste disposal sites into deep and shallow based on measured data. It can also be difficult to determine the sites that meet the IPCC criteria for managed sites.

Degradable organic carbon (DOC)
There are two sources of uncertainty in DOC values.

- Uncertainty in setting the DOC for different types of waste types/materials (paper, food, etc.). There are few studies of DOC and different types of paper, food, wood and textiles can have very different DOC values. The water content of the waste also has an influence. DOC for industrial waste is very poorly known.
- Uncertainty in the waste composition affects estimates of total DOC in the SWDS. Waste composition varies widely even within countries (for example, between urban and rural populations, between households on different incomes and between seasons) as well as between countries.

Fraction of degradable organic carbon which decomposes (DOC_f)
The uncertainty in DOC_f is very high. There have been few studies, and it is difficult to replicate real SWDS conditions in experimental studies.

Fraction of CH_4 in landfill gas (F)

Source: 2006 IPCC Guidelines Volume 5: Waste

Practice3: Emission Calculation and Uncertainty Calculation

- 3-1 Calculation of Case Study (Every Sector)
- 3-2 Introduction of the Example of GHG inventory (Case Study; based on the example of "2006 IPCC Guidelines"; from Japanese Expert)
- 3-3 Practice of Uncertainty Analysis of above GHG inventory (Case Study; calculated by TGO Staffs)
- 3-4 Discussion "Issue of Uncertainty Analysis in Thailand"

Practice3-1: Calculation Practice of GHG Inventory (easy case study) (part1)

- (1) Energy Sector
  - Activity Data: IEA Energy Statistics
  - EF and Uncertainty: 2006 IPCC Guidelines
- (2) IPPU Sector
  - Activity Data: United Nations data (Industrial Commodity Statistics Database)
  - EF and Uncertainty: 2006 IPCC Guidelines

Practice3-1: Calculation Practice of GHG Inventory (easy case study) (part2)

- (3) AFOLU Sector
  - Activity Data: Thailand's Initial National Communication & FAO Statistics
  - EF and Uncertainty: 2006 IPCC Guidelines
- (4) Waste Sector
  - Activity Data: United Nations data (Industrial Commodity Statistics Database)
  - EF and Uncertainty: 2006 IPCC Guidelines

3-2 Introduction of the Example of GHG inventory and Uncertainty

- JICA Expert prepares the Excel file.
- This Excel file is a case study of "Uncertainty Analysis" and "Key Category Analysis".
- This case study is the example of "2006 IPCC Guidelines".
- JICA Expert will explain the outline of this Excel file at first.

3-3 Practice of Uncertainty Analysis of above GHG inventory and Uncertainty

- TGO (GHG Information Center) staffs will calculate the "Uncertainty" in this case study (this Excel file).
- JICA Expert will advise the calculation methods.
- The calculation method of the "Uncertainty" is not difficult in itself.
- The set of values of the "Uncertainty" is very difficult.

3-4 Discussion "Issue of Uncertainty Analysis in Thailand"

- Please discuss the issue of the "Uncertainty Analysis" in Thailand. (Thai Language is OK.)

3-4 Comments about Uncertainty Analysis (not official opinion)

- If the uncertainty value of each sub-category can be set, it is not difficult to calculate the mathematical expression of uncertainty analysis.
- It is difficult to set the uncertainty values of activity and emission factors of each sub-category. Moreover, the explanation of the reasons of these value is also difficult.

Practice4: Key Category Analysis

- 4-1 Basic Methods of Key Category Analysis (from Japanese Expert)
- 4-2 Practice of Key Category Analysis of above GHG inventory and Uncertainty Analysis (calculated by TGO Staffs)
- 4-3 Discussion "Issue of Key Category Analysis in Thailand"

4-1 Basic Methods of Key Category Analysis (from Japanese Expert)

- JICA Expert prepares the Excel file.
- This Excel file is a case study of "Uncertainty Analysis" and "Key Category Analysis".
- This case study is the example of "2006 IPCC Guidelines".
- JICA Expert will explain the outline of this Excel file at first.

4-2 Practice of Key Category Analysis of above GHG inventory and Uncertainty Analysis

- TGO staffs will calculate the "Key Category Analysis" in this case study (this Excel file).
- JICA Expert will advise the calculation methods.
- The calculation method of the "Key Category Analysis" is a little complex (not easy).

4-3 Discussion "Issue of Key Category Analysis in Thailand"

- Please discuss the issue of the "Key Category Analysis" in Thailand. (Thai Language is OK.)

4-3 Comments about Key Category Analysis (not official opinion)

- Though the calculation procedure may be complicated, it is not difficult to calculate the "key category analysis" using the "2006 IPCC Guidelines".
- It is necessary to prepare the amounts of emission of the base year and current year and uncertainty analysis of each sub-category, and it is very complex.

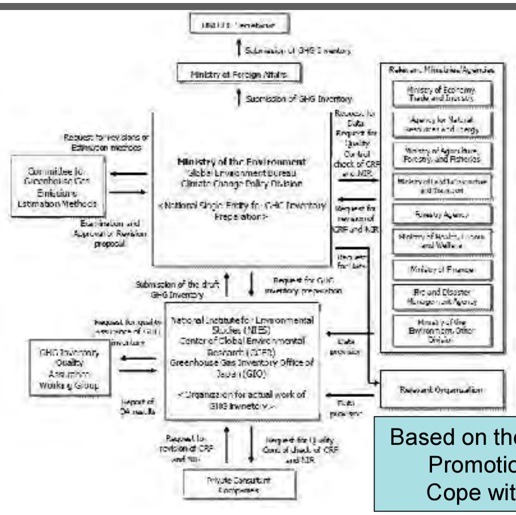
4-3 Comments about Uncertainty and Key Category Analysis (not official opinion)

- First, it is important to understand the flow from the uncertainty analysis to the key category analysis by using a simple Tier1 method. (not only the level but also the uncertainty)
- If the secular change of GHG inventory are obtained, it is good practice to execute the trend assessment.

Practice 5: Other Issues

- 5-1 QA/QC system in Japan
- 5-2 QA/QC system in Thailand (future plan)
- 5-3 Discussion "Development of GHG Inventory in Thailand"

5-1 QA/QC system in Japan



Source: National Greenhouse Gas Inventory Report of Japan

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

5-1 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

5-1 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

5-1 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)

5-1 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)

5-1 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

5-2 Future Plan of Thailand's QA/QC

- Freely
- Who?
- What?
- How?

5-3 Discussion "Development of GHG Inventory in Thailand"

- Freely
- Bottle neck of development of GHG Inventory
- Data collection (missing data/ confidential data/ exclusive data/generating new data, etc. ……)
- Development of Inventory Production Cycle

5-4 Comments of Other Issue

- Inventory compilers must make the GHG inventory step by step.
  - First: Data Collection
  - Second: Inventory Production Cycle
  - Third and fourth…… : the "Key category Analysis", "Uncertainty Analysis"……
- There are many manuals such as each "IPCC Guidelines", "EMEP/EEA emission inventory guidebook 2009" etc.. The more recent manual include more useful information. So inventory compilers should collect recent information about Manual.

Conclusions (part 1)

- Inventories are very useful for the rational policy development for Low Carbon Society.
- Inventory 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.

Source: Kiyoto Tanabe's Presentation Material (12 July 2010, Thailand)

Conclusions (part 2)

- Inventories are very essential to monitor the impacts of mitigation policies and measures.
  - Policy makers need to know if policies are working.
  - Inventory methods should be chosen to reflect impacts of mitigation actions.

Source: Kiyoto Tanabe's Presentation Material (12 July 2010, Thailand)

Conclusions (part 3)

- Good quality national GHG inventories are getting more and more important as they are key to mitigation actions in a MRV ("Measurable, Reportability and Verifiability") manner.

Source: Kiyoto Tanabe's Presentation Material (12 July 2010, Thailand)

Conclusions (part 4)

- Key factors for success in inventory development are, among others;
  - Frequent and sustained inventory cycle.
    - Routinized inventory work helps improve inventory team's capacity and facilitate data collection.
  - Institutional arrangements
  - Quality Assurance and Quality Control
    - Systematic quality check procedures help continuously improve inventory quality.

Source: Kiyoto Tanabe's Presentation Material (12 July 2010, Thailand)

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

Output 2: Training materials, Guideline for Trainer

Clean Development Mechanism (CDM)

Target Groups

Code	Target group
G	General audience
PP	Project proponent and Consultant
A	Thai governmental agencies and DNAs in Southeast Asia

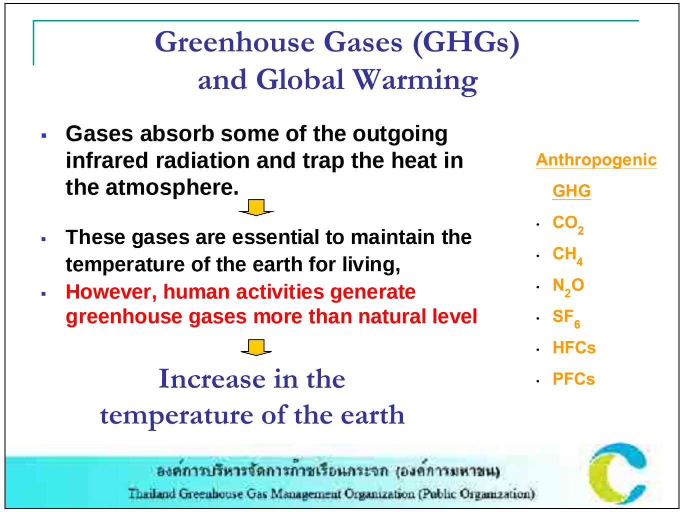
Update History

Version	Date	Update Contents
01	29/07/2010	Initial adoption

CDM01-01	Target Group: G, PP, A

(Mention A/R CDM is not covered in this presentation.)

CDM01-02	Target Group: G



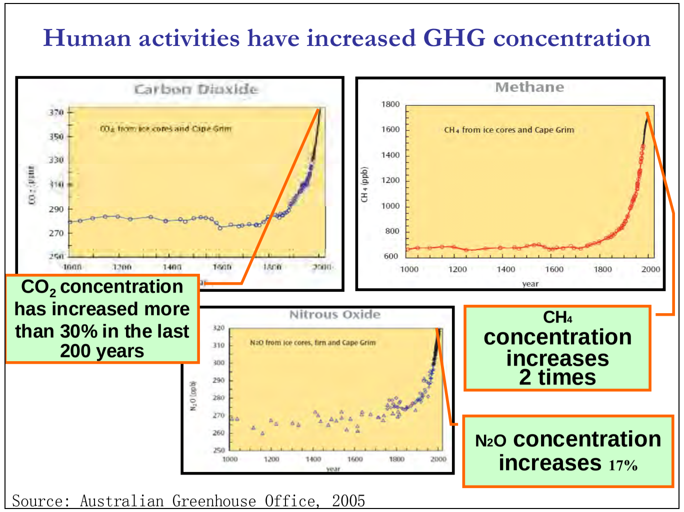
Key Points

- Human activities have increased the **GHG concentration** in the atmosphere faster than natural level
- Such increasing volume of greenhouse gases is trapped in the atmosphere, causing **rapid temperature increase** in global level
- GHG (Greenhouse Gases)

☞ CDM-01-12

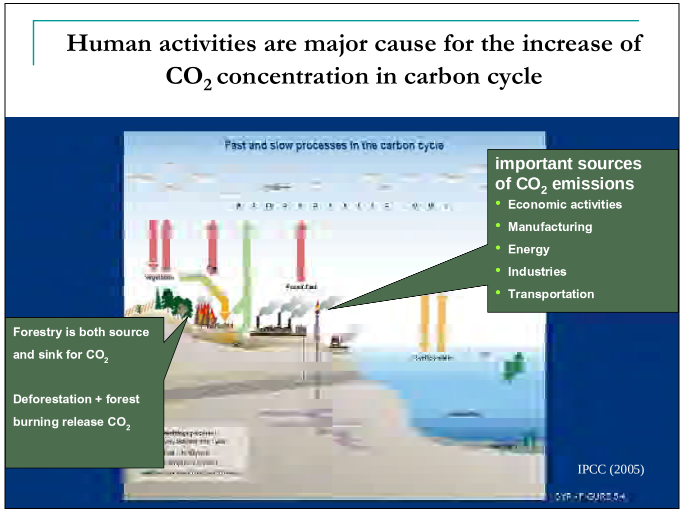
Reference and Additional Information

CDM01-03	Target Group: G



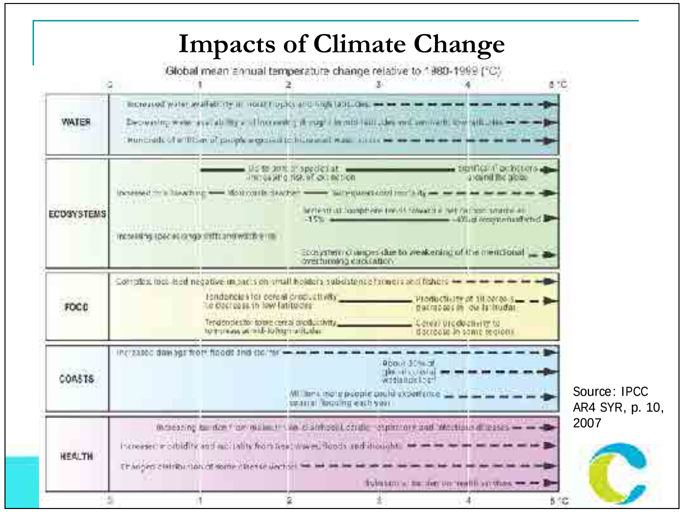
Key Points	Reference and Additional Information
- 3 graphs are showing how three major GHGs have increased in the last 1000 years - All gases have **rapidly increased in the past 200 years** corresponding to the increase of human activity levels that rocketed after the start of the industrial revolution	

CDM01-04	Target Group: G



Key Points	Reference and Additional Information
- The graph is showing a general **carbon cycle**, both **natural and anthropogenic** (human induced) - Natural cycles include rather slow carbon release from water body or natural soil - **Anthropogenic cycle** is much faster than natural cycles, which include • Economic activities, manufacturing, energy generation and consumption, various industrial activities, transportation activities, etc. as well as, • Carbon release from deforestation	

CDM01-05	Target Group: G



Key Points

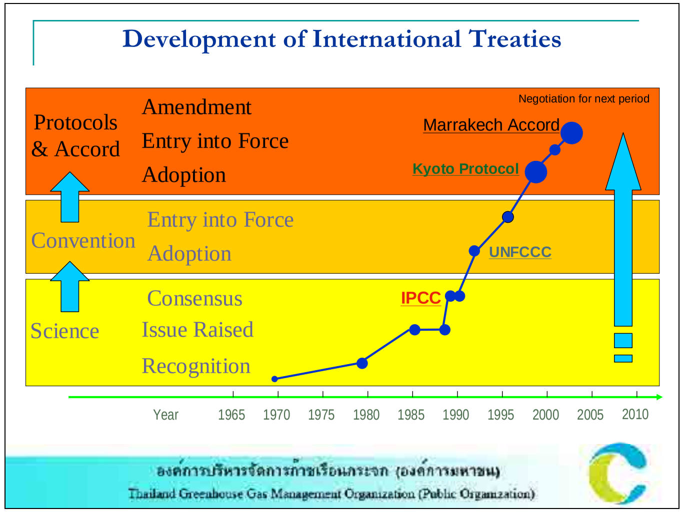
- The graph is taken from the latest **IPCC report released in 2007**
- The graph is showing the expected and possible impacts of climate change depending on the temperature increase

(Choose several impact elements which target audience has the highest interest, and explain in detail)

Reference and Additional Information

- IPCC report
  (Climate Change 2007: Synthesis Report)
  http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms3.html

CDM01-06	Target Group: G, PP, A



Key Points

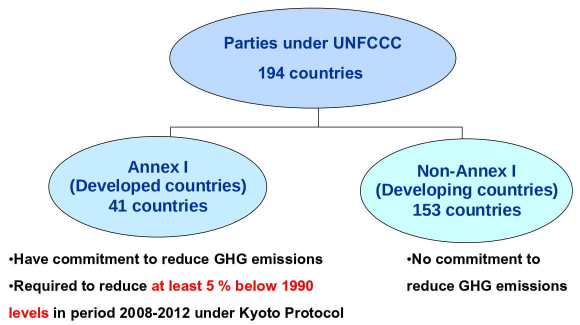
- The chart describes how international world has acted against climate change over the years
- International world reacted to climate change first at scientific level in the early 1970's, in which scientists argued the relationship between greenhouse gases concentrations and global temperature change
- **IPCC** (Intergovernmental Panel on Climate Change) issued a first report on climate change impacts **in 1990**
- As a result of this IPCC report and international recognition, **UNFCCC** (United Nations Framework Convention of Climate Change) was **adopted in 1992**
- Since UNFCCC does not impose any numerical reduction requirement for developed countries (Annex-I countries), **Kyoto Protocol** was **adopted in 1997** and then **entered into force in 2005**
- Currently international world is negotiating about the framework after 2013, often referred as **post-Kyoto** regime

Reference and Additional Information

- UNFCCC text
  http://unfccc.int/essential_background/convention/background/items/2853.php
- Kyoto Protocol text
  http://unfccc.int/kyoto_protocol/items/2830.php

CDM01-07	Target Group: G, PP, A

UNFCCC Participant Parties



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Key Points

- Currently 194 countries, or “**Parties**,” join the **UNFCCC**
- Under UNFCCC, 41 developed countries, or “**Annex-I countries**,” have commitment to reduce GHG, while the remaining 153 developing countries, or “**Non-Annex I countries**,” do not have commitment to reduce GHG emissions.
- Annex I counties also have commitment to submit National Communication and give financial support and technology transfer to non-Annex I countries
- Non-Annex I countries are also required to prepare and submit to UNFCCC a National Communication report if a country receives financial support.
- But all Non-Annex I countries basically share the principle of UNFCCC and support climate change alleviation
- Under **Kyoto Protocol**, Annex-I countries are required to reduced GHG emissions by 5% below that of 1990 emission level between the years 2008 to 2012, which is called the first commitment period

Reference and Additional Information

- List of Annex-I countries
http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php
- List of Non Annex-I countries
http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php

CDM01-08	Target Group: G, PP, A

Emission Reduction Target under Kyoto Protocol

% reduction from 1990

EU-15	*-8%*
(US)	*(-7%)*
Canada, Hungary, Japan, Poland	*-6%*
Croatia	*-5%*
New Zealand, Russian Federation, Ukraine	*0%*
Norway	*+1%*
Australia	*+8%*
Iceland	*+10%*

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Key Points

- Table shows the **legally-binding commitment** of some of the major **Annex-I countries** for their reduction target under Kyoto Protocol
- Countries have different level of reduction target depending on their economic activity size and growth from base year of 1990 and also as a result of long and intense international negotiations
- As for **the United States**, they adopted the Kyoto Protocol but later withdrew from the Protocol and thus they do not have any reduction commitment
- Although reduction targets for each EU member state Parties are -8%, targets are adjusted among the EU countries

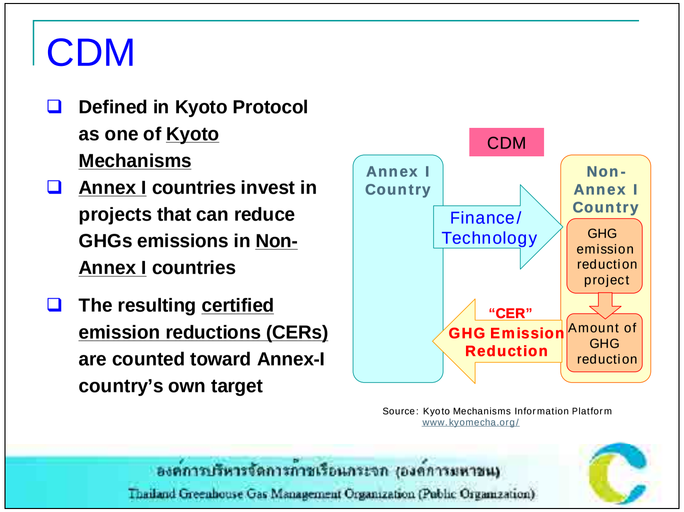
Reference and Additional Information

- Emission target of Annex-I countries
http://unfccc.int/kyoto_protocol/items/3145.php

CDM01-09	Target Group: G, PP, A

Key Points	Reference and Additional Information

CDM01-10	Target Group: G, PP, A



Key Points	Reference and Additional Information
- Clean Development Mechanism is one of the schemes stipulated in Kyoto Protocol, together with Joint Implementation (JI) and Emission Trading (these 3 mechanisms are called **Kyoto Mechanism**) - Under CDM, developed country provides **finance and/or clean technology** and carries out GHG emission reduction project in developing country - Amount of GHG emissions reduced in that developing country (or so called host country) is counted as a carbon credit called **Certified Emission Reductions (CER)** and can be transferred to the Annex-I country (or called investment country) to meet its reduction target under Kyoto Protocol	- CDM official website http://cdm.unfccc.int/index.html

CDM01-11	Target Group: G, PP, A

Principle of CDM

- ❑ Voluntary participation by Parties involved
- ❑ Real, measurable & long-term benefits related to the mitigation of climate change
- ❑ Emission reductions are additional to any that would occur in the absence of the CDM project
- ❑ Sustainable development

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Key Points

- Four of the major **principles of CDM**
- A participating country must host or invest to CDM project **on a voluntary basis**, instead of being forced to join
- Emission reduction must be real and **can be measured or calculated**, and also the project must bring long-term benefit
- CDM project must be **additional**, in other words, proposed CDM project would not occur without CDM and CER revenue

(Additionality is explained in later slides in more detail) ☞ CDM-01-26

- CDM project must contribute to **sustainable development** of host country. This point is the key issue in obtaining national approval from TGO.

Reference and Additional Information

CDM01-12	Target Group: G, PP, A

Major GHGs defined in Kyoto Protocol

Greenhouse Gas	Formula	Global Warming Potential (CO_2 equivalent)
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons	HFCs	140 - 11,700
Perfluorocarbons	PFCs	6,500 - 9,200
Sulphur hexafluoride	SF_6	23,900

Source: IPCC, 2005

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Key Points

- Kyoto Protocol defines target GHGs
- A project that reduces only these 6 types of gases is eligible to CDM
- A level of global warming impacts is different depending on the gas. For example, 1 ton of nitrous oxide has the same **global warming impacts** as 310 tons of carbon dioxide.
- Amount of GHG reduction in all CDM projects is expressed in **ton of CO2-equivalent**.

Reference and Additional Information

CDM01-13	Target Group: G, PP, A

Scope of CDM projects

1. Energy Industries
2. Energy Distribution
3. Energy Demand
4. Manufacturing Industries
5. Chemical Industries
6. Construction
7. Transport
8. Mining/mineral production
9. Metal production
10. Fugitive emissions from fuels
11. Fugitive emissions from production and consumption of halocarbons and SF_6
12. Solvent use
13. Waste handling and disposal
14. Afforestation and reforestation
15. Agriculture

Source: http://cdm.unfccc.int/DOE/scopes.html

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Key Points

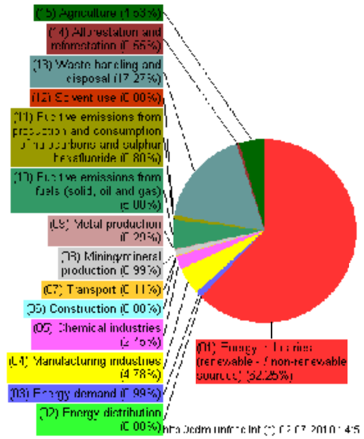
- There are 15 sectors, or **sectoral scopes**, eligible for CDM project activities.
- Most of the registered projects in **Thailand** are from
  - sector 1 (energy industries, such as biomass power generation), and
  - sector 13 (waste handling and disposal, including waste and wastewater management)

Reference and Additional Information

- Sectoral scopes
http://cdm.unfccc.int/DOE/scopes.html

CDM01-14	Target Group: G, PP, A

Registered CDM projects by scope



Sectoral Scope	Registered Projects
1	1,705
2	0
3	27
4	131
5	67
6	0
7	3
8	27
9	8
10	137
11	22
12	0
13	473
14	15
15	124
Total	2,739

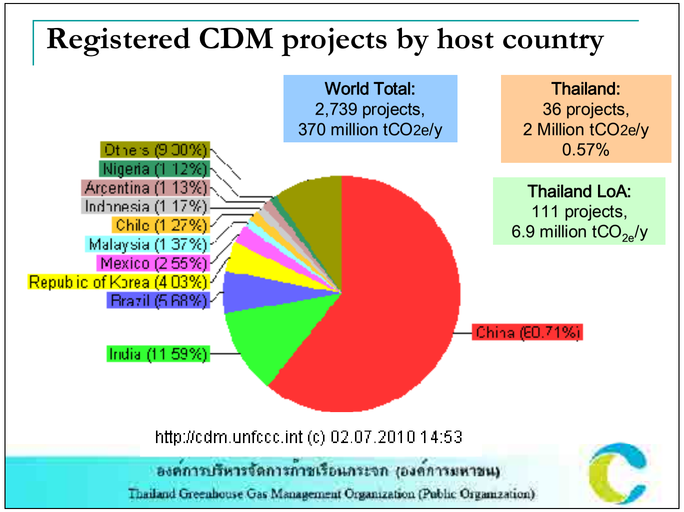
Key Points

- This graph is taken from CDM Executive Board official website, showing the distribution of registered project by sectoral scope in the world
- As of (July 2nd 2010), (2,739) CDM projects have been registered in the world.
- The largest portion is from the **Sectoral Scope 1 "Energy Industries (renewable/ non-renewable sources)"** which includes for example, a construction of grid-connected renewable energy power generation plant.
- Second most common sector is 13 "Waste handling and disposal"

Reference and Additional Information

- CDM statistics
http://cdm.unfccc.int/Statistics/index.html

CDM01-15	Target Group: G, PP, A



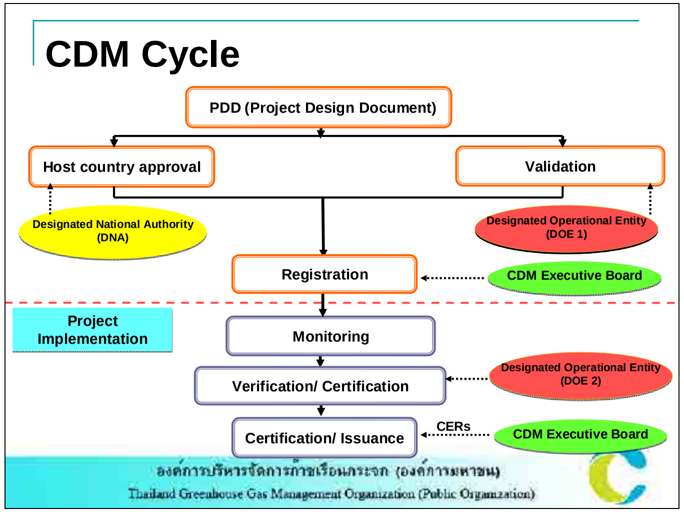
Key Points

- This graph is showing the number of registered projects by host country as of (July 2nd 2010)

Reference and Additional Information

- CDM statistics
http://cdm.unfccc.int/Statistics/index.html

CDM01-16	Target Group: G, PP, A



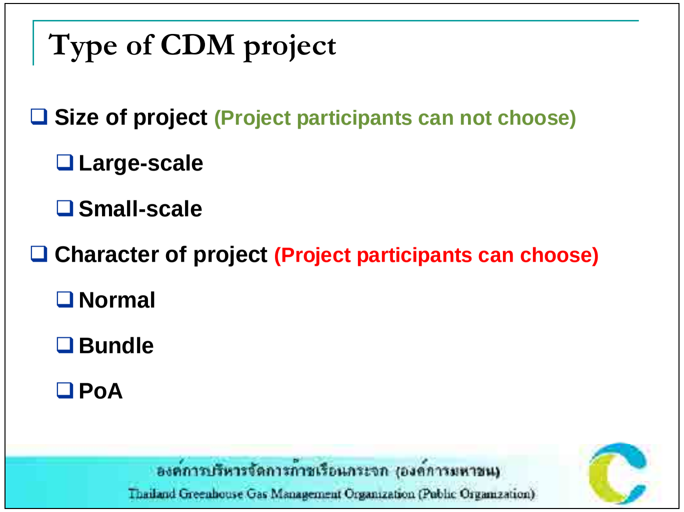
Key Points

- Chart shows general CDM project cycle from project design to CER issuance
- **Project Proponent (PP)** first prepares **Project Design Document (PDD)**, which describes project description, technology applied, baseline and additionality, how to monitor and calculate GHG emission reductions, etc. PP must use a standard format of PDD provided by CDM Executive Board
- Using the developed PDD, PP must obtain **national approval from TGO**, and also has to go through a **validation** process that will be conducted by a third independent party called **Designated Operational Entity (DOE)**.
- The project that has obtained national approval and also successfully passed the validation process can **apply to registration** to CDM Executive Board.
- After CDM project is registered and operation starts, PP must conduct **monitoring** activity in order to obtain data and information necessary to calculate GHG emission reduction amount from the project activity.
- Result of monitoring will be then checked by **DOE** through **verification** and amount of CER is decided in **certification** stage.
- After going through all these stages, **CER is issued** to the PP by the CDM Executive Board.

Reference and Additional Information

- PDD formats:
http://cdm.unfccc.int/Reference/_PDDs_Forms/PDDs/index.html
- List of DOEs:
http://cdm.unfccc.int/DOE/list/index.html

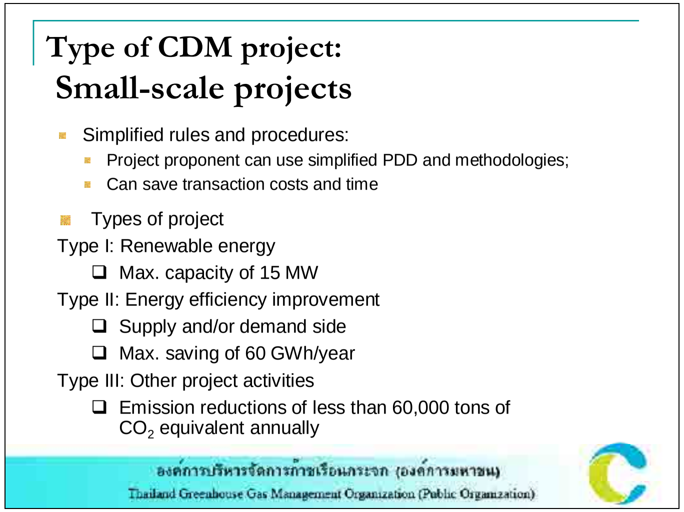
CDM01-17	Target Group: G, PP, A



Key Points

Reference and Additional Information

CDM01-18	Target Group: G, PP, A



Key Points

- PP of **small-scale CDM project** can **benefit** from various points, including they can use more simple PDD format and methodology than large-scale, which also means they can save significant time and cost in preparing the document
- There are **three types of small-scale** CDM project activities depending on the technology/ sector of the proposed project
- A proposed project must fall within the maximum allowed project size defined by CDM Executive Board in order to be eligible to small-scale
- **Type I** project is a **renewable energy** project and its limit is 15 MW output capacity of the renewable unit
- **Type II** is **energy efficiency** project and its limit is 60 GWh of energy saving per year
- **Type III** project is all **other** project types not included in Type I and II, including waste and wastewater management, transportation, agriculture, etc., and limit is 60,000 CO_2-equivalent tons of emission reduction

Reference and Additional Information

CDM01-19	Target Group: G, PP, A

Type of CDM project: Bundle projects

- F-CDM-BUNDLE – information related the bundle
- PDD (CDM-SSC-PDD)
  - Single CDM-SSC-PDD: all project activities in the bundle belong to the same type, category and technology/ measure
  - If not: CDM-SSC-PDD for each of the project activities contained in the bundle must be submitted

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Key Points	Reference and Additional Information
- **Bundling** is defined as bringing together of several small-scale project activities to make a single CDM project activity without the loss of distinctive characteristics of each project activity, including technology/ measure, location, and application of small-scale methodology. - The sum of the output capacity of projects within a sub-bundle projects must not exceed the maximum output capacity limit for its type. - PP must prepare and submit **bundling format** together with PDD. - The benefits of bundling may include reduction of project development costs, reduction of Engineering, Procurement and Construction (EPC) costs, reduction of O&M costs, reduction of transaction costs (general cost and CDM-related cost), and increase of total investment volume. (Source: CDM/JI Manual, Ministry of Environment, Japan, 2009)	- CDM/JI Manual, Ministry of Environment, Japan http://gec.jp/main.nsf/en/Activities-CDMJI_FS_Programme-CDMJI_Manual2009

CDM01-20	Target Group: G, PP, A

Type of CDM project : Progamme of Activities (PoA)

- Unlimited number of CDM Programme Activities (CPAs) that is a project activity under a PoA
- A PoA shall be proposed by the Coordinating or Managing Entity (C/ME) which shall be a project participant authorized by all participating host country DNAs
- C/ME shall obtain
  - Letters of Approval (LoA) for the implementation of the PoA from each Host Party and Annex I Party involved in the PoA
  - Letters of Authorization of its coordination of the PoA from each Host Party.
- The duration of the PoA shall not exceed 28 years, whereas crediting period of a CPA is as same as normal CDM project.

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Key Points	Reference and Additional Information
(to be added after Training Course on PoA)	

CDM01-21	Target Group: G, PP, A

Baseline: what is baseline?

- Baseline scenario is needed to identify emission reduction by proposed project activity.
- Baseline is different by each project, depending on technology/ measure, project type, condition, policy, etc.
- Baseline scenario is

  the scenario that reasonably represents the anthropogenic emissions by sources of greenhouse gases that would occur in the absence of the proposed project activity

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Key Points

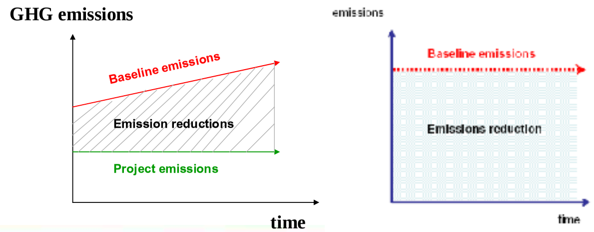
- Baseline is one of the concepts PP must understand to implement CDM project
- It is **necessary to determine emission reduction amount**, or **amount of credit PP will receive**
- Baseline scenario is a **project-specific** situation that would happen in the absence of the proposed project activity

Reference and Additional Information

CDM01-22	Target Group: G, PP, A

Baseline and GHG Emission Reduction

GHG Emission Reduction (tCO_2e/y) = Baseline emission (tCO_2e/y) - Project emission + Leakage (tCO_2e/y)



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Key Points

- This slide describes why baseline is essential and how baseline is used in order to determine the emission reduction of the CDM project
- The difference between GHG emissions from baseline scenario, called **Baseline Emissions** (shown in the red line), and GHG emissions that are generated through the proposed CDM project activity, called **Project Emissions** (shown in the green line), is GHG emission reductions
- Amount of baseline emissions and project emissions are different by each project type;
  - e.g. renewable energy generation project does not generate any GHG emission from project activity, and therefore, project emission is zero. In this case, amount of emissions from baseline will become the emission reductions.

Reference and Additional Information

CDM01-23	Target Group: PP

How to identify baseline? (1)

- Project proponent (PP) must identify baseline using the methods and steps specified in the baseline **methodology** that is applied to the project activity.
- PP will analyze all reasonable baseline scenario options, which may include:
  - Continuation of the current activity
  - Implementation of the proposed project activity
  - Other scenarios
- PP must describe how a baseline scenario is selected among possible baseline scenario options.

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Key Points

- Following slides explain how PP can set baseline in order to calculate GHG emission reduction
- PP first **identify methodology that is applicable to proposed project**

(methodology will be explained in later slides)

☞ CDM-01-32

- PP can then find in the methodology about how to set the baseline

Reference and Additional Information

CDM01-24	Target Group: PP

How to identify baseline? (2)

- Baseline is determined by applying one of the following 3 patterns, depending on the baseline methodologies applied;
- **Case 1: Methodology presents a fixed baseline scenario**.
  - PP demonstrates that the baseline scenario is the only relevant and plausible business-as-usual scenario.
  - Small-scale methodologies and some large-scale methodologies
- **Case 2: Methodology presents several possible baseline options**
  - PP selects the most plausible baseline scenario, which is a combination of baseline options.

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Key Points

Reference and Additional Information

CDM01-25	Target Group: PP

How to identify baseline? (3)

- **Case 3: Methodology does not present any baseline option and PP must present possible baseline options using a step-wise approach**.
  - To apply step 1 of the "Combined tool to identify the baseline scenario and demonstrate additionality"
  - Only applicable if all potential alternative scenarios are available options to project participants, such as
    - Modifications to an existing installation operated by PP
    - Construction of new facilities, if all alternative scenarios are available options to PP

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Key Points	Reference and Additional Information

CDM01-26	Target Group: G, PP, A

Additionality

- Project Proponents are required to prove "additionality" of proposed project activity in the project design document (PDD).
- Additionality is stipulated as;

> A CDM project activity is additional if anthropogenic emissions of greenhouse gases by sources are reduced below those that would have occurred in the absence of the registered CDM project activity.
>
> (para5. Paragraph 43 of the CDM modalities and procedures)

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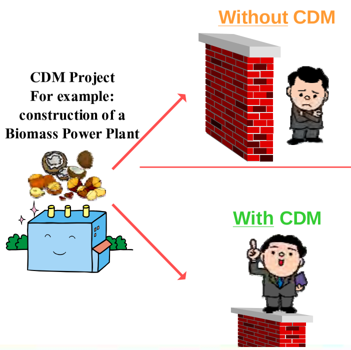
Key Points	Reference and Additional Information
- One of the principles of CDM is that project activity must be additional. - PP must prove in PDD that the proposed project is additional to that would occur in the absence of the project - **Additionality** is one of the key issues in CDM development and many PPs find it difficult to reasonably demonstrate additionality of their proposed project - This is also evident from the fact that most of the CDM projects that were rejected by the CDM Executive Board are due to insufficient demonstration of additionality	

CDM01-27	Target Group: G, PP, A

What is additionality?



Financially not feasible
Technology is not available

Project developer can not implement the project due to many barriers

Carbon Credit
Additional revenue
Clean image

Project developer is able to implement the project

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Key Points

- Example to show the concept of additionality (using a biomass power plant construction project)
- **Without CDM** and benefit from CER sales, project proponent usually finds many **barriers** to implement the project, including project is not financially feasible or attractive, and new clean technology is not readily accessible
- CDM can remove these barriers and enable PP to implement the project
- **Benefits** PP can receive from CDM includes additional revenue from carbon credit sales and also PP can receive clean image about their entity or products/ services from the customers/ clients, and market
- This CDM project can be considered **additional** since PP cannot carry out the project without CDM, but can implement the project if they register the project as CDM

Reference and Additional Information

CDM01-28	Target Group: PP

How to demonstrate additionality?

- Project proponent may use:
  - Tool for the demonstration and assessment of additionality (CDM-EB16 – October 2004)
  - Guidance on the assessment of investment analysis (CDM-EB added as an annex to the Additionality tool in July 2008)
  - Combined additionality tool (CDM-EB27 – November 2006)

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Key Points

- PP must describe in PDD about the project additionality
- Similar to baseline, PP can find the first step to prove, or demonstrate additionality in the applicable **methodology**
- Each methodology stipulates how to prove additionality of the project.
- CDM EB has published several tools and guidance that allow PP to demonstrate additionality

Reference and Additional Information

CDM01-29	Target Group: PP

"Tool for the demonstration and assessment of additionality" (Additionality Tool)

Provides a step-wise approach:

- Identification of alternatives to the project activity
- Investment analysis to determine that the proposed project activity is either
  - Not the most economically or financially attractive
  - Not economically or financially feasible
- Barrier analysis
- Common practice analysis
  - complement and reinforce the investment and/or barrier analysis

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Key Points	Reference and Additional Information
- Most commonly used tool to prove additionality - Many approved methodologies require to use this additionality tool - The tool provides a step-wise approach to analyze and prove additionality - PP must pass each step by proving the proposed project is facing various type of barriers that prohibit implementation of the project	

CDM01-30	Target Group: PP

Guidance on the assessment of investment analysis

- General guidance for calculation and presentation of IRR/ NPV
  - Investment comparison analysis and benchmark analysis
  - Selection and validation of appropriate benchmarks
  - Sensitivity analysis

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Key Points	Reference and Additional Information
- For most CDM projects, PP must show financial performance of the project activity - This Guidance sets several rules to calculate financial indicator such as Internal Rate of Return (**IRR**) or Net Present Value (NPV)	

CDM01-31	Target Group: PP

Combined tool to identify the baseline scenario and demonstrate additionality

- Methodologies using this tool are only applicable if all potential alternative scenarios to the proposed project activity are available options to project participants.

Key Points

- This tool provides a step-wise approach to identify the baseline scenario and simultaneously demonstrate additionality.

Reference and Additional Information

CDM01-32	Target Group: G, PP, A

Methodologies: Overview

- **The roles of methodologies are** to ensure that CDM project activities have:
  - **real**, **measurable**, and **long-term** benefits related to the mitigation of GHG emission reductions;
  - reductions in emissions that are **additional** to any that would occur in the absence of the certified project activity.

Methodologies include appropriate formulae how to quantify baseline and project emissions, and leakage emissions.

Key Points

- In developing a CDM project, PP must identify the **methodology** that is applicable to the proposed project.
- PP also must use the methodology that is officially **approved by the CDM Executive Board**.
- A methodology is important and essential for many reasons.

1. It is used to **calculate GHG emission reductions** from the project:
   - methodology defines the baseline emissions, project emissions, and leakage emissions with mathematic formulae to calculate such emissions. All PP must follow the equations and data parameters if they wish to use the approved methodology.
2. It is used to **identify the baseline scenario**:
   - related to the baseline GHG emissions, methodology allows you to select and identify "what would happen if the project is not implemented as CDM"
3. Methodology **stipulates how to demonstrate additionality**:
   - some methodologies have their own methods to prove additionality while others refer to some tools such as additionality tool. But overall, methodology gives the first step PP must take in order to prove additionality
4. Methodology **stipulates monitoring parameters**:
   - PP must monitor or measure certain parameters after project starts in order to obtain data that is used for the calculation of GHG emissions reduction.

Reference and Additional Information

CDM01-33 | **Target Group: PP**

Large-scale Methodologies (AM and ACM)

- Approved Methodologies (AM): 70 meth. active;
- Approved Consolidated Methodologies (ACM): 17 meth. active;
- 10 tools such as 'additionality tool' are available;

- ACM0002 (grid-connected renewable energy projects) is applied to 647 registered projects;
- On the other hand, 46 AMs and 5 ACMs have no registered project

(as of 2 July 2010)

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Key Points

- Methodologies (except A/R) are distinguished by 3 categories
- 1) Large-scale methodologies (AM), 2) Consolidated methodologies for large-scale (ACM), and 3) small scale methodologies (AMS)
- (As of July 2, 2010) There are currently (70) active **AMs, or Approved Methodologies** and (17) active **ACMs, or Approved Consolidated Methodologies**
- Also, there are several "Tools" that are associated with AM and ACM.
- Some methodologies require to refer and apply these tools in calculating emissions or demonstrating additionality.
- The latest list of AM and ACM, as well as Tool is available at the CDM EB website.

- It is interesting to know that sectoral distribution of registered CDM projects is not even. And the most frequently-used ACM, which is called **ACM0002**, has been applied to more than 600 registered projects so far, while 46 Approved Methodologies and 5 Approved Consolidated Methodologies are never used so far.

Reference and Additional Information

- List of AM and ACM, Tools

http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

CDM01-34 | **Target Group: PP**

Small-scale Methodologies (AMS)

Type	Description	Number of approved small-scale meth.
I	**Renewable energy**	**6**
II	**Energy efficiency**	**11**
III	**Other types**	**36**

- AMS-I.D. is applied to 659 registered projects;
- On the other hand, only 66 registered projects for all Type-II;
- Type III includes many Non-CO_2 methodologies such as CH_4, HFC23, and N_2O.

(all data is as of 2 July 2010)

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Key Points

- Small-scale approved methodologies, or **AMS** (standing for **Approved Methodologies for Small-scale project activity**), are different from the large-scale methodologies in various points, including in principle;
- Methodology itself is usually **more simple and shorter**
- Baseline scenario is readily presented
- Method to demonstrate additionality is not written as principally all small-scale projects can follow the same guidance to prove additionality
- Monitoring parameters are fewer and formulae are less complicated

- Uneven distribution of registered projects among sectors is also seen in the small scale methodologies.
- Most frequently used small-scale methodology, which is called **AMS-I.D.** (grid-connected renewable electricity generation project), has been applied to more than 600 projects so far.

Reference and Additional Information

- List of AMS

http://cdm.unfccc.int/methodologies/SSCmethodologies/approved.html

CDM01-35 | **Target Group: PP**

Methodologies used by registered CDM projects in Thailand

Methodology	Number of Registered Projects	Methodology	Number of Registered Projects
AMS-I.D.	17	ACM0002	3
AMS-III.H.	11	AM0024	2
AM0022	6	AM0013	2
AMS-I.C.	5	ACM0001	2
ACM0006	5	AM0028	1
AMS-III.D.	4		

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Key Points

- The list of approved methodologies that are most frequently used by registered CDM projects in Thailand.
- The list includes all kinds of methodologies (AM, ACM, and AMS).
- Note that some of the methodologies are not active at present because some of these AMs have been combined and become ACM, or some ACM has been divided into 2 ACMs and so on.
- It is **very important to check the latest methodologies** by following decisions by CDM-EB, and also discussions by methodology panel and small-scale working group of CDM-EB in order to keep updated since PP is **not allowed to use old version of approved methodology**.
- Frequently used approved methodologies include those for grid-connected renewable energy, wastewater treatment, thermal energy production, and energy generation using waste biomass.

☞ CDM-01-41

Reference and Additional Information

CDM01-36 | **Target Group: PP**

New methodology approval process: Large-scale project

- **PPs** propose a new methodology, **through a DOE/AE**, submitting the draft CDM-PDD, CDM-NM;
- The **DOE/AE** determines whether the proposed project activity intends to use a new methodology, and check whether the documents are complete and forward them to **UNFCCC secretariat**
- The **secretariat** check the completeness of the documents and publish the documents **on the UNFCCC CDM web site** and invite **public inputs** for a period of 15 working days.
- The documents and comments are forwarded to **Meth Panel**;
- **EB** approves the new methodology according to the final recommendation of Meth Panel.
- If Meth Panel does not approve the new methodology, PPs must provide clarification.

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Key Points

- In case PP cannot find any approved methodology that is applicable to their proposed project, a new methodology can be developed and submitted for approval. Once it is approved by CDM-EB, PP can apply that methodology to their CDM project.
- AE: applicant entity
- NM: new methodology
- Meth.: methodology

Reference and Additional Information

CDM01-37	Target Group: PP

New methodology approval process: Small-scale project

- **PPs**, **DOEs**, **DNAs** or **stakeholders** propose a new SSC methodology, submitting the draft CDM-SSC-PDD, CDM-SSC-NM;
- After performing a completeness check, the **UNFCCC secretariat** forwards the documentation to **EB** and **SSC-WG**;
- **The secretariat** also makes the proposed new SSC methodology **publicly available on the UNFCCC CDM website** and invite public inputs for a period of 10 working days;
- **Public inputs** are forwarded to **SSC WG** soon after receipt and made publicly available;
- **SSC WG** makes a **recommendation** regarding the approval of the proposed new SSC methodology to EB at its next meeting;
- **EB** finally decides whether the methodology is acceptable or not.

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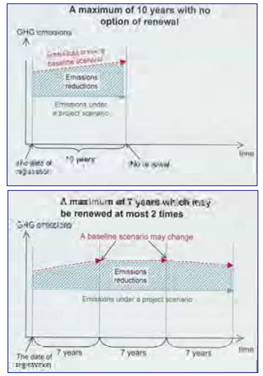
Key Points

- The difference between the process for large-scale and small-scale is that for large-scale, only PP can submit new methodology though DOE; however, for small-scale, all PP, DOE, DNA, or stakeholders can directly submit the new methodology
- SSC-WG: small-scale working group

Reference and Additional Information

CDM01-38	Target Group: G, PP, A

Crediting Period of CDM project



Options:

1) **A maximum of 10 years with no optional of renewal** OR
2) **A maximum of 7 years which may be renewed at most 2 times**

Source: IGES

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Key Points

- PP must remember that carbon credits, or **CERs, can be issued only during a crediting period** that starts from the date of CDM registration.
- PP can select the type of crediting period from 2 options;
  - A maximum of **10 years** with no option of renewal
  - A maximum of **7 years** which can be renewed up to 2 times. (For each renewal, PP must prove the original baseline is still valid, or establish a new baseline)

Reference and Additional Information

CDM01-39	Target Group: G, PP, A

Monitoring

- PPs must monitor every parameters specified in PDD -- section B.7: Application of the monitoring methodology and description of the monitoring plan
- PPs must ensure that the required data is accurately monitored and recorded to enable the calculation of the emission reductions achieved by the proposed project activity.
- PPs must have procedures to cope with emergency case, instrument failure and inconsistent data.
- Emission reduction declared in monitoring report will become CER and money that PPs will get.

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Key Points

- After registration, PP must conduct **monitoring** in which **PP will measure and calculate certain parameters** in order to calculate the amount of GHG emission reductions, and then record and report the monitoring result.
- Parameters to be monitored are described in the **approved methodology** applied to the project and they must also be described in PDD
- Depending on the sector, or methodology, or project size, **the number of parameters** to be monitored for one project is different.
- **Frequency of monitoring** is different by each parameter, from every 15 minutes to every year.
- Monitoring may be conducted by PP themselves or by an external entity such as consultant, but the monitoring report must be prepared by PP and submitted to DOE in order to get CERs
- PP is also required to establish and mention in PDD a **monitoring organization or structure**, in which responsible personnel or department and its monitoring responsibility is clearly described
- Although PP is not required to be ISO-certified entity, PP must describe in PDD about quality assurance/ quality control (**QA/QC**) procedures.
- Monitoring activity is extremely important for PP and investors since **it is directly related to the CER or revenue they can receive**.

Reference and Additional Information

CDM01-40	Target Group: PP

CDM update: Major EB decisions (1)

- Approval or revision of the manuals / guidelines

Name of manual/ guideline	Version	EB
Validation and Verification Manual	01.1	EB51
Guidelines on the assessment of investment analysis	03	EB51
Guidelines on the Registration Fee Schedule For Proposed Project Activities Under the Clean Development Mechanism	01	EB52
Guidelines for completing the monitoring report form (CDM-MR)	01	EB54
General guidelines to SSC CDM methodologies	13	EB54
Guidelines for demonstrating additionality of renewable energy projects =< 5 MW and energy efficiency projects with energy savings <= 20 GWH per year	01	EB54

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Key Points

- These slides show recent major decisions by CDM Executive Board that may affect PPs in Thailand.
- CDM-EB is held once in every two or three months and the result of EB meeting is open to public, which is available on the website.
- **Validation and verification manual (VVM)**: originally designed for DOEs for validation but PPs can also refer to the manual to check the key points in validation.
- "**Guidelines on the assessment of investment analysis**." :Revision to provide guidance on the treatment of interest payments in income tax calculations.
- "Guidelines on the **Registration Fee** Schedule For Proposed Project Activities Under the CDM", in order to defer the payment of the registration fee for projects hosted in countries with less than 10 registered CDM project activities.
- "**General guidelines to SSC CDM methodologies**": Procedures to determine the baseline for Type II and Type III Greenfield and capacity addition projects were revised.
- "**Guidelines for demonstrating additionality of renewable energy projects =< 5 MW and energy efficiency projects with energy savings <= 20 GWH per year**": Guideline is to establish simplified modalities for demonstrating additionality for project activities up to 5 MW that employ renewable energy as their primary technology and for energy efficiency project activities that aim to achieve energy savings at a scale of no more than 20 GWh/ year.

Reference and Additional Information

- CDM EB meeting report
http://cdm.unfccc.int/EB/index.html

CDM01-41 | **Target Group: PP**

CDM update: Major EB decisions (2)

- Revision of the approved methodologies (frequently used in Thailand)
  - AMS-I.D (EB54, Annex7)
  - AMS-III.H (EB53, Annex17)
  - AMS-I.C (EB51, Annex19 / EB54, Annex9)
  - ACM0002 (EB52, Annex7)
  - ACM0006 (EB52, Annex8)

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Key Points

- List of the recent changes in the approved methodologies that are frequently used in Thailand.
- **"AMS-I.D Grid connected renewable electricity generation"** to clarify that revised AMS-I.D now covers only supply of renewable electricity to a national or regional grid. Projects that displace grid or captive electricity with renewable electricity are covered under AMS-I.F.
- **"AMS-III.H: Methane recovery in wastewater treatment",** to clarify the monitoring requirements of biogas flow rate and default model uncertainty factors to use in baseline and project emission calculations.
- **"AMS-I.C: Thermal energy production with or without electricity",** to expand its applicability to biomass-based cogeneration project activities supplying surplus electricity to a grid. The revision also clarifies that leakage from biomass transportation is to be considered only for cases where biomass is transported over a distance of 200 km or more.
- Also to clarify applicability to cogeneration systems, the use of solid biomass fuels (e.g. briquette) and to include the procedures to determine the baseline of projects switching from fossil fuel to renewable biomass.
- **ACM0002: "Consolidated baseline methodology for grid-connected electricity generation from renewable sources"** to clarify the applicability condition requesting availability of 5 years of historical data for capacity addition, retrofit and rehabilitation projects is not required for wind, solar, wave or tidal power capacity addition projects which directly meter the electricity generated by the added capacities.
- **ACM0006: "Consolidated methodology for electricity generation from biomass residues in power and heat plants"** The applicability of the methodology was restricted to power and heat projects due to the approval of a new consolidated methodology ACM0018 for power-only projects. Power-only projects were excluded from this methodology.

Reference and Additional Information

CDM01-42 | **Target Group: PP**

CDM update: Major EB decisions (3)

- Accreditation of operational entities
  - EB 53 decided to suspend the accreditation and designation of the designated operational entity "TÜV SÜD Industrie Service GmbH".
  - EB 54 decided to accredit and provisionally designate five entities.

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Key Points

- EB accredits entity who wishes to be a DOE and also suspends DOE
- EB suspends all or some of the accredited sectoral scopes of the DOE
- Latest DOE information is available at CDM-EB website

Reference and Additional Information

- List of DOEs and status

http://cdm.unfccc.int/DOE/list/index.html

CDM01-43	Target Group: G, PP, A

Key Points	Reference and Additional Information
-	