

# CGE SUPPLEMENTARY TRAINING MATERIAL FOR THE TEAM OF TECHNICAL EXPERTS

## Module 2.2f

Background material:

*Key differences between the  
Revised 1996 IPCC Guidelines and  
2006 IPCC Guidelines*

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# CONTENT

LIST OF TABLES.....	6
LIST OF FIGURES .....	6
ABBREVIATIONS .....	7
1. BACKGROUND AND COURSE OBJECTIVES.....	8
2. OVERVIEW .....	9
2.1. Introduction.....	9
2.2. Approach of the 2006 IPCC Guidelines .....	10
2.3. Key improvements .....	10
2.3.1. Summary of improvements .....	10
2.3.2. Structural changes .....	11
2.3.3. New gases and sources .....	13
2.3.4. Estimation of actual annual emissions .....	13
2.3.5. Non-Energy Uses of fossil fuels .....	14
3. ENERGY SECTOR .....	15
3.1. Changes in Categorization.....	15
3.2. Categories added explicitly .....	18
3.2.1. Catalytic converters using urea .....	18
3.2.2. Multilateral operations .....	18
3.2.3. Methane from abandoned coal mines .....	18
3.2.4. Flaring of drained methane or conversion of methane to carbon dioxide .....	19
3.2.5. Uncontrolled combustion and burning of coal deposits .....	19
3.2.6. carbon dioxide capture and storage .....	19
3.3. Other updated information .....	20
3.3.1. Updated default emission factors and other parameters .....	20
3.3.2. Updated methods.....	20
4. INDUSTRIAL PROCESSES SECTOR.....	21

4.1.	Changes in categorization .....	21
4.2.	categories Added Explicitly .....	22
4.2.1.	Caprolactam, glyoxal and glyoxylic acid production .....	22
4.2.2.	Titanium dioxide production .....	23
4.2.3.	Petrochemical and carbon black production.....	23
4.2.4.	Lead .....	23
4.2.5.	Zinc .....	23
4.2.6.	Thin-film-transistor flat panel displays, photovoltaics and heat transfer fluid.....	24
4.2.7.	Sulfur hexafluoride and perfluorocarbons from other product use (military applications and accelerators).....	24
4.3.	Other updated information.....	25
4.3.1.	Updated default emission factors and other parameters .....	25
4.3.2.	Updated methods.....	25
5.	AGRICULTURE SECTOR.....	27
5.1.	Changes in categorization .....	27
5.2.	categories Added Explicitly .....	29
5.2.1.	Indirect nitrous oxide emissions from Manure Management .....	29
5.2.2.	Carbon dioxide emissions from liming.....	29
5.2.3.	Carbon dioxide emissions from urea fertilization.....	29
5.2.4.	Nitrous oxide from nitrogen mineralization associated with loss of soil organic matter resulting from change of land use or management of mineral soils (subcategory in direct nitrous oxide emissions from managed soils) .....	30
5.3.	Other updated information .....	30
5.3.1.	Updated default emission factors and other parameters .....	30
5.3.2.	Updated methods.....	31
6.	LAND-USE CHANGE AND FORESTRY SECTOR .....	32
6.1.	Changes in categorization .....	32
6.2.	Categories Added Explicitly .....	34

6.2.1.	Harvested wood products.....	34
6.2.2.	Wetlands remaining wetlands .....	35
6.2.3.	Settlements remaining settlements .....	35
6.2.4.	Indirect nitrous oxide emissions from non-agriculture land uses .....	36
6.2.5.	Nitrous oxide emissions from mineralization associated with land-use changes and management changes.....	36
6.3.	Other updated information .....	36
6.3.1.	Updated default emission factors and other parameters .....	36
6.3.2.	Updated methods.....	36
7.	WASTE SECTOR.....	38
7.1.	Changes in categorization .....	38
7.2.	Categories Added Explicitly .....	38
7.2.1.	Uncategorized waste disposal sites .....	38
7.2.2.	Biological treatment of solid waste .....	39
7.3.	Other updated information .....	39
7.3.1.	Updated default emission factors and other parameters.....	39
7.3.2.	Updated methods.....	40

## LIST OF TABLES

Table 1	Greenhouse gases covered in the 2006 IPCC Guidelines .....	13
Table 2	Sections of the 2006 IPCC Guidelines addressing major greenhouse gas emissions from managed wetlands .....	35

## LIST OF FIGURES

Figure 1	Breakdown of sectors and categories .....	12
Figure 2	Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: energy .....	16
Figure 3	Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: industrial processes.....	21
Figure 4	Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: agriculture and forestry .....	27
Figure 5	Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: agriculture.....	28
Figure 6	Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: forestry .....	33
Figure 7	Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: land use change and forestry .....	33
Figure 8	Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: waste.....	38

# ABBREVIATIONS

<b>AD</b>	activity data
<b>AFOLU</b>	agriculture, forestry and other land use
<b>CCS</b>	carbon capture and storage
<b>CH<sub>4</sub></b>	methane
<b>CO<sub>2</sub></b>	carbon dioxide
<b>EF</b>	emission factor
<b>FC</b>	fluorinated compounds
<b>FOD</b>	first order decay
<b>GHG</b>	greenhouse gas
<b>GPG 2000</b>	Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories
<b>GPG LULUCF</b>	Good Practice Guidance for Land Use, Land-Use Change and Forestry
<b>HWP</b>	harvested wood products
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>IPPU</b>	industrial processes and product use
<b>MCF</b>	methane conversion factor
<b>N</b>	nitrogen
<b>N<sub>2</sub>O</b>	nitrous oxide
<b>NH<sub>3</sub></b>	ammonia
<b>PFCs</b>	perfluorocarbons
<b>SF<sub>6</sub></b>	sulphur hexafluoride
<b>SO<sub>2</sub></b>	sulphur dioxide
<b>SWDS</b>	solid waste disposal sites

# 1. BACKGROUND AND COURSE OBJECTIVES

**This material was developed within the context of the process for international consultation and analysis to further support the training for the team of technical experts (TTE) and to provide additional background knowledge and context.**

This module, prepared as supplementary training material to module 2.2 on technical analysis of greenhouse gas (GHG) inventories, aims to provide an overview of the key differences between the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the Revised 1996 IPCC Guidelines) and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (hereinafter referred to as the 2006 IPCC Guidelines). This is intended for **those experts nominated to the UNFCCC roster of experts with no or limited prior knowledge and wishing to enhance their technical knowledge on national GHG inventories**. The information presented here should be further supplemented with that from the 2006 IPCC Guidelines in order to address the complete length and breadth of science and methods involved in estimating GHG emissions.



## 2. OVERVIEW

### 2.1. INTRODUCTION

The 2006 IPCC Guidelines were produced to update the Revised 1996 IPCC Guidelines and associated good practice guidance, namely, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (herein referred to as GPG 2000) and *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (herein referred to as GPG LULUCF) which provide internationally agreed methodologies intended for use by countries to estimate GHG inventories to report to the UNFCCC.

The 2006 IPCC Guidelines represent a significant step forward in producing reliable, accurate, consistent and comparable inventories of emissions and removals of GHGs. The 2006 IPCC Guidelines update earlier guidance, combine good practice guidance and new scientific and technical information on emissions and removals of GHGs.

Parties included in Annex I to the Convention (Annex I Parties) are required to use the 2006 IPCC Guidelines to prepare national GHG inventories from 2015, but non-Annex I Parties are not obligated to use the 2006 IPCC Guidelines. However, some non-Annex I Parties already use the 2006 IPCC Guidelines to prepare their GHG inventory as part of their national communication and for the biennial update report. This module will explain the key differences between the 2006 IPCC Guidelines and the Revised 1996 IPCC Guidelines to provide the team of technical experts with background information in case the Party reports a national GHG inventory based on the new guidelines.

## 2.2. APPROACH OF THE 2006 IPCC GUIDELINES

The 2006 IPCC Guidelines are an evolutionary development starting from the Revised 1996 IPCC Guidelines, GPG 2000 and GPG LULUCF. A fundamental shift in methodological approach would pose difficulties with time series consistency in emissions and removals estimation, and incur additional costs, since countries and the international community have made significant investments in inventory systems. An evolutionary approach helps ensure continuity, and allows for the incorporation of experiences with the existing guidelines and new scientific information.

The 2006 IPCC Guidelines retain the definition of good practice that was introduced with GPG 2000. This definition has gained general acceptance among countries as the basis for inventory development. According to this definition, national inventories of anthropogenic GHG emissions and removals consistent with good practice are those which contain neither over- nor under-estimates, so far as can be judged, and in which uncertainties are reduced as far as practicable.

As with the Revised 1996 IPCC Guidelines, GPG 2000 and GPG LULUCF, the 2006 IPCC Guidelines apply the tiered approach by means of decision trees. A decision tree guides selection of the tier to use for estimating the category under consideration, given national circumstances. Also, the most common simple methodological approach to estimating emissions and removals is still to combine information on the extent to which a human activity takes place (activity data or AD) with coefficients which quantify the emissions or removals per unit activity (emission factors or EF).

The basic equation is therefore:  $\text{Emissions} = \text{AD} * \text{EF}$

## 2.3. KEY IMPROVEMENTS

### 2.3.1. SUMMARY OF IMPROVEMENTS

The 2006 IPCC Guidelines provide users with a number of key advantages compared to earlier guidance:

- **Improved accuracy:** The guidelines now include updated methods and improved default values based on up-to-date information thus improving the overall accuracy of estimates. Guidance for all sources and sinks now gives actual annual estimates, as opposed to the earlier “potential” methods;
- **More complete:** Guidance is given on more sources and sinks as they have been identified since 1996. Guidance on land-use sectors has been made more complete and consistent across all land uses. More fluorinated GHGs are included as information on their use and release has become available;
- **Reduced scope for errors:** The categories have been restructured to reduce the possibilities for double counting or omissions. The most appropriate choice of method has been made easier by incorporating and updating the earlier good practice guidance into the individual sector methods;
- **Clearer guidance:** Integrating all the good practice guidance into the methodology report ensures that users can more easily find all the relevant information they need. The guidance starts with one general volume on overall

quality assurance and quality control and good practice issues, and sector specific matters are all dealt with in the sector volumes;

- **Resource-relevant methods:** Differing methodologies and their selection enable inventory developers with limited resources to complete their national estimates while also allowing those with greater resources to use more detailed and accurate methods.

### 2.3.2. STRUCTURAL CHANGES

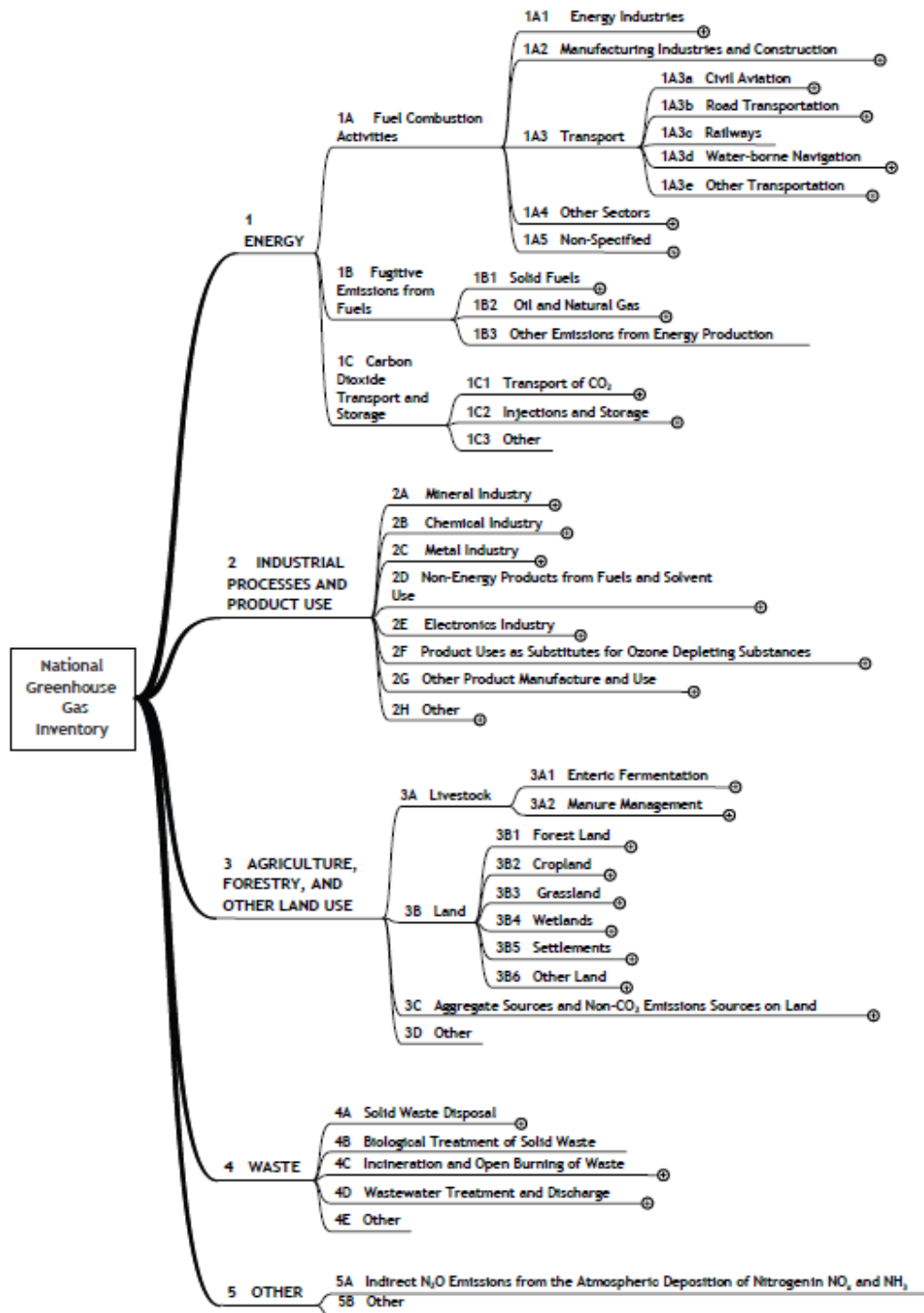
The 2006 IPCC Guidelines contain five volumes, one for each sector (volumes 2–5) and one for general guidance applicable to all sectors (volume 1).

- Volume 1: General Guidance and Reporting;
- Volume 2: Energy;
- Volume 3: Industrial Processes and Product Use;
- Volume 4: Agriculture, Forestry and Other Land Use;
- Volume 5: Waste.

Although the number of sectors in the 2006 IPCC Guidelines has been reduced from six to four, this is not accompanied by any great changes at the individual category level. This integration removes the somewhat arbitrary distinction between these categories in the previous guidance, and promotes consistent use of data between them, especially for more detailed methods.

The figure 1 shows the breakdown of subsectors and categories for each of the sectors.

Figure 1  
Breakdown of sectors and categories



Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Overview, p. 6.

### 2.3.3. NEW GASES AND SOURCES

Additional GHGs identified in the *IPCC Third Assessment Report* are also included where anthropogenic sources have been identified (table 1).

**Table 1**  
**Greenhouse gases covered in the 2006 IPCC Guidelines**

Table 1 - Greenhouse gases covered in the 2006 Guidelines			
Name	Symbol(s)	In IPCC 1996 Guidelines	GWP available in TAR
Carbon Dioxide	CO <sub>2</sub>	Yes	Yes
Methane	CH <sub>4</sub>	Yes	Yes
Nitrous Oxide	N <sub>2</sub> O	Yes	Yes
Hydrofluorocarbons	HFCs (e.g., HFC-23 (CHF <sub>3</sub> ), HFC-134a (CH <sub>2</sub> FCF <sub>3</sub> ), HFC-152a (CH <sub>2</sub> CHF <sub>2</sub> ))	Yes	Yes
Perfluorocarbons	PFCs (CF <sub>4</sub> , C <sub>2</sub> F <sub>6</sub> , C <sub>3</sub> F <sub>8</sub> , C <sub>4</sub> F <sub>10</sub> , C-C <sub>4</sub> F <sub>8</sub> , C <sub>5</sub> F <sub>12</sub> , C <sub>6</sub> F <sub>14</sub> )	Yes	Yes
Sulphur Hexafluoride	SF <sub>6</sub>	Yes	Yes
Nitrogen Trifluoride	NF <sub>3</sub>		Yes
Trifluoromethyl Sulphur Pentafluoride	SF <sub>5</sub> CF <sub>3</sub>		Yes
Halogenated Ethers	e.g., C <sub>4</sub> F <sub>9</sub> OC <sub>2</sub> H <sub>5</sub> , CHF <sub>2</sub> OCF <sub>2</sub> OC <sub>2</sub> F <sub>4</sub> OCHF <sub>2</sub> , CHF <sub>2</sub> OCF <sub>2</sub> OCHF <sub>2</sub>		Yes
Other halocarbons	e.g., CF <sub>3</sub> I, CH <sub>2</sub> Br <sub>2</sub> , CHCl <sub>3</sub> , CH <sub>3</sub> Cl, CH <sub>2</sub> Cl <sub>2</sub>		Yes
	C <sub>2</sub> F <sub>7</sub> C(O)C <sub>2</sub> F <sub>5</sub> , C <sub>7</sub> F <sub>16</sub> , C <sub>4</sub> F <sub>6</sub> , C <sub>3</sub> F <sub>8</sub> , C-C <sub>4</sub> F <sub>8</sub> O		

Source: 2006 IPCC Guidelines For National Greenhouse Gas Inventories: Primer.

The 2006 IPCC Guidelines have been expanded to include more manufacturing sectors and product uses identified as sources of GHGs. Also now included are methane (CH<sub>4</sub>) from abandoned coal mines, carbon dioxide (CO<sub>2</sub>) capture and storage (CCS), and biological treatment and open burning of waste (e.g. composting and biogas facilities). See the sectoral sections for details.

It should be noted that these source/sink categories are not necessarily “new” because these emissions/removals could have been included in the “Other” categories even when using the Revised 1996 IPCC Guidelines. Any significant sources of emissions should be covered in national GHG inventories. Absence of technical inventory methodology in the IPCC Guidelines for certain sources does not mean that national inventories do not need to cover such sources.

### 2.3.4. ESTIMATION OF ACTUAL ANNUAL EMISSIONS

For a few sources, the Revised 1996 IPCC Guidelines and GPG 2000 describe the simplest methodology, estimating a ‘potential emission’ rather than the actual annual emission. This ‘potential emission’ assumes all the emissions from an activity occur in the same year, ignoring the fact they will occur over many years. In the 2006 IPCC Guidelines, simple default methods have been devised to estimate emissions when they occur, thus removing the need for potential emissions. This also allows the

emission reductions of abatement techniques to be properly reflected in the emission estimate and ensures that the tier 1 methods are compatible with higher tier methods. This occurs mainly in the industrial processes and product use (IPPU) sector (fluorinated gases) and the waste sector (solid waste disposal).

### 2.3.5. NON-ENERGY USES OF FOSSIL FUELS

Guidance on demarcation between the energy and IPPU sectors has been improved, and emissions from non-energy uses of fossil fuels are now reported under the IPPU sector, rather than in the energy sector. A method has been introduced for checking the completeness of CO<sub>2</sub> emission estimates from the non-energy uses.

## 3. ENERGY SECTOR

### 3.1. CHANGES IN CATEGORIZATION

Figure 2 illustrates the categorization changes for the energy sector from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines.

Figure 2  
**Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: energy**

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
<b>1- Energy</b>	<b>1- Energy</b>
<b>I.A Fuel Combustion Activities (Sectoral Approach)</b>	<b>I.A Fuel Combustion Activities</b>
<b>I.A.1 Energy Industries</b>	<b>I.A.1 Energy Industries</b>
I.A.1.a Public Electricity and Heat Production	I.A.1.a Main Activity Electricity and Heat Production
	I.A.1.a.i Electricity Generation
	I.A.1.a.ii Combined Heat and Power Generation (CHP)
	I.A.1.a.iii Heat Plants
I.A.1.b Petroleum Refining	I.A.1.b Petroleum Refining
I.A.1.c Manufacture of Solid Fuels and Other Energy Industries	I.A.1.c Manufacture of Solid Fuels and Other Energy Industries
	I.A.1.c.i Manufacture of Solid Fuels
	I.A.1.c.ii Other Energy Industries
<b>I.A.2 Manufacturing Industries and Construction</b>	<b>I.A.2 Manufacturing Industries and Construction</b>
I.A.2.a Iron and Steel	I.A.2.a Iron and Steel
I.A.2.b Non-Ferrous Metals	I.A.2.b Non-Ferrous Metals
I.A.2.c Chemicals	I.A.2.c Chemicals
I.A.2.d Pulp, Paper and Print	I.A.2.d Pulp, Paper and Print
I.A.2.e Food Processing, Beverages and Tobacco	I.A.2.e Food Processing, Beverages and Tobacco
I.A.2.f Other	I.A.2.f Non-Metallic Minerals
	I.A.2.g Transport Equipment
	I.A.2.h Machinery
	I.A.2.i Mining (excluding fuels) and Quarrying
	I.A.2.j Wood and Wood Products
	I.A.2.k Construction
	I.A.2.l Textile and Leather
	I.A.2.m Non-specified Industry
<b>I.A.3 Transport</b>	<b>I.A.3 Transport</b>
I.A.3.a Civil Aviation	I.A.3.a Civil Aviation
I.A.3.a.i International Aviation (International Bunkers)	I.A.3.a.i International Aviation (International Bunkers)
I.A.3.a.ii Domestic	I.A.3.a.ii Domestic Aviation
I.A.3.b Road Transportation	I.A.3.b Road Transportation
I.A.3.b.i Cars	I.A.3.b.i Cars
Passenger Cars with 3-way Catalysts	I.A.3.b.i.1 Passenger Cars with 3-way Catalysts
Passenger Cars without 3-way Catalysts	I.A.3.b.i.2 Passenger Cars without 3-way Catalysts
I.A.3.b.ii Light-duty Trucks	I.A.3.b.ii Light-duty Trucks
Light-duty Trucks with 3-way Catalysts	I.A.3.b.ii.1 Light-duty Trucks with 3-way Catalysts
Light-duty Trucks without 3-way Catalysts	I.A.3.b.ii.2 Light-duty Trucks without 3-way Catalysts
I.A.3.b.iii Heavy-duty Trucks and Buses	I.A.3.b.iii Heavy-duty Trucks and Buses
I.A.3.b.iv Motorcycles	I.A.3.b.iv Motorcycles
I.A.3.b.v Evaporative Emissions from Vehicles	I.A.3.b.v Evaporative Emissions from Vehicles
	I.A.3.b.vi Urea-based Catalysts
I.A.3.c Railways	I.A.3.c Railways
I.A.3.d Navigation	I.A.3.d Water-borne Navigation
I.A.3.d.i International Marine (International Bunkers)	I.A.3.d.i International Water-borne Navigation (International Bunkers)
I.A.3.d.ii National Navigation	I.A.3.d.ii Domestic Water-borne Navigation
I.A.3.e Other Transportation	I.A.3.e Other Transportation
I.A.3.e.i Pipeline Transport	I.A.3.e.i Pipeline Transport
I.A.3.e.ii Off-road	I.A.3.e.ii Off-road
<b>I.A.4 Other Sectors</b>	<b>I.A.4 Other Sectors</b>
I.A.4.a Commercial/Institutional	I.A.4.a Commercial/Institutional
I.A.4.b Residential	I.A.4.b Residential
I.A.4.c Agriculture/Forestry/Fisheries	I.A.4.c Agriculture/Forestry/Fishing/Fish Farms
	I.A.4.c.i Stationary
	I.A.4.c.ii Off-road Vehicles and Other Machinery
	I.A.4.c.iii Fishing (mobile combustion)
<b>I.A.5 Other</b>	<b>I.A.5 Non-Specified</b>
I.A.5.a Stationary	I.A.5.a Stationary
I.A.5.b Mobile	I.A.5.b Mobile
	I.A.5.b.i Mobile (aviation component)
	I.A.5.b.ii Mobile (water-borne component)
	I.A.5.b.iii Mobile (other)
	I.A.5.c Multilateral Operations



Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
<b>1.B Fugitive emissions from fuels</b>	<b>1.B Fugitive emissions from fuels</b>
<b>1.B.1 Solid Fuel</b>	<b>1.B.1 Solid Fuel</b>
1.B.1.a Coal Mining and Handling	1.B.1.a Coal Mining and Handling
1.B.1.a.i Underground Mines	1.B.1.a.i Underground Mines
Mining Activities	1.B.1.a.i.1 Mining
Post-Mining Activities	1.B.1.a.i.2 Post-mining Seam Gas Emissions
	1.B.1.a.i.3 Abandoned Underground Mines
	1.B.1.a.i.4 Flaring of Drained Methane or Conversion of Methane to CO <sub>2</sub>
1.B.1.a.ii Surface Mines	1.B.1.a.ii Surface Mines
Mining Activities	1.B.1.a.ii.1 Mining
Post-Mining Activities	1.B.1.a.ii.2 Post-mining Seam Gas Emissions
1.B.1.b Solid Fuel Transformation	1.B.1.b Uncontrolled Combustion, and Burning Coal Dumps
1.B.1.c Other	1.B.1.c Solid Fuel Transformation
<b>1.B.2 Oil and Natural Gas</b>	<b>1.B.2 Oil and Natural Gas</b>
1.B.2.a Oil	1.B.2.a Oil
	1.B.2.a.i Venting
	1.B.2.a.ii Flaring
	1.B.2.a.iii All Other
1.B.2.a.i Exploration	1.B.2.a.iii.1 Exploration
1.B.2.a.ii Production and Upgrading	1.B.2.a.iii.2 Production and Upgrading
1.B.2.a.iii Transport	1.B.2.a.iii.3 Transport
1.B.2.a.iv Refining / Storage	1.B.2.a.iii.4 Refining
1.B.2.a.v Distribution of Oil Products	1.B.2.a.iii.5 Distribution of Oil Products
1.B.2.a.vi Others	1.B.2.a.iii.6 Others
1.B.2.b Natural Gas	1.B.2.b Natural Gas
	1.B.2.b.i Venting
	1.B.2.b.ii Flaring
	1.B.2.b.iii All Other
1.B.2.b.i Exploration	1.B.2.b.iii.1 Exploration
1.B.2.b.ii Production / Processing	1.B.2.b.iii.2 Production
	1.B.2.b.iii.3 Processing
1.B.2.b.iii Transmission and Storage	1.B.2.b.iii.4 Transmission and Storage
1.B.2.b.iv Distribution	1.B.2.b.iii.5 Distribution
1.B.2.b.v Other Leakage at industrial plants and power stations in residential and commercial sectors	1.B.2.b.iii.6 Others
1.B.2.c Venting and Flaring	
Venting	
i. Oil	
ii. Gas	
iii. Combined	
Flaring	
i. Oil	
ii. Gas	
iii. Combined	
1.B.2.d Other	
	<b>1.B.3 Other Emissions from Energy Production</b>
	<b>1.C Carbon Dioxide Transport and Storage</b>
	<b>1.C.1 Transport of CO<sub>2</sub></b>
	1.C.1.a Pipelines
	1.C.1.b Ships
	1.C.1.c Other
	<b>1.C.2 Injection and Storage</b>
	1.C.2.a Injection
	1.C.2.b Storage
	<b>1.C.3 Other</b>

	Existing category has been subdivided into 2 or more categories
	New category
	Category that has been eliminated or consolidated

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and 2006 IPCC Guidelines For National Greenhouse Gas Inventories.

## 3.2. CATEGORIES ADDED EXPLICITLY<sup>1</sup>

### 3.2.1. CATALYTIC CONVERTERS USING UREA

The 2006 IPCC Guidelines contain a method for estimating CO<sub>2</sub> emissions from catalytic converters using urea, a source of emissions that was not addressed previously. The CO<sub>2</sub> emissions are estimated as a product of the mass of urea-based additive consumed for use in catalytic converters, the fraction of urea in the urea-based additive, a stoichiometric conversion value converting urea to carbon and a conversion factor converting carbon to CO<sub>2</sub>.

Many types of off-road vehicles will not have catalytic converters installed, but emission controls will probably increasingly be used for some categories of off-road vehicles, especially those operated in urban areas (e.g. airport or harbour ground support equipment) in developed countries. If catalytic converters using urea are used in off-road vehicles, the associated CO<sub>2</sub> emissions should be estimated also.

### 3.2.2. MULTILATERAL OPERATIONS

Multilateral operations are defined as fuels used for aviation and water-borne navigation in multilateral operations pursuant to the Charter of the United Nations. These include emissions from fuel delivered to the military in the country and delivered to the military of other countries.

Emissions from multilateral operations should not be included in national totals; other emissions related to operations shall be included in the national emissions totals of one or more Parties involved. The national calculations should take into account fuel delivered to the country's military, as well as fuel delivered within that country but used by the military of other countries. Other emissions related to operations (e.g. off-road ground support equipment) shall be included in the national emissions totals in the appropriate source category.

This data should be used with care as national circumstances may vary from those assumed in the 2006 IPCC Guidelines. In particular, distances travelled and fuel consumption may be affected by national route structures, airport congestion and air traffic control practices.

### 3.2.3. METHANE FROM ABANDONED COAL MINES

Closed, or abandoned, underground coal mines may continue to be a source of GHG emissions for some time after the mines have been closed or decommissioned. For the purpose of the emissions inventory, it is critical that each mine is classified in one and only one inventory database (e.g. active or abandoned).

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<sup>1</sup> It should be noted that these source/sink categories are not necessarily "new", because these emissions/removals could have been included in the "Other" categories even when using the Revised 1996 IPCC Guidelines.

The two key parameters used to estimate abandoned mine emissions for each mine (or group of mines) are the time (in years) elapsed since the mine was abandoned, relative to the year of the emissions inventory, and emission factors that take into account the mine's gassiness. If applicable and appropriate, CH<sub>4</sub> recovery at specific mines can be incorporated for specific mines.

Abandoned underground mines present difficulties in estimating emissions, although a methodology for abandoned underground mines is included in the 2006 IPCC Guidelines. Methodologies do not yet exist for abandoned or decommissioned surface mines, and therefore they are not included.

#### 3.2.4. FLARING OF DRAINED METHANE OR CONVERSION OF METHANE TO CARBON DIOXIDE

CH<sub>4</sub> drained from working (or abandoned) underground (or surface) coal mines can be vented directly to the atmosphere, recovered and utilized, or converted to CO<sub>2</sub> through combustion (flaring or catalytic oxidation) without any utilization. The manner of accounting for drained CH<sub>4</sub> varies, depending on the final use of the CH<sub>4</sub>.

Tier 1 represents an aggregate emissions estimate using emission factors. In general, it is not expected that emissions associated with drained CH<sub>4</sub> would be applicable for tier 1. Presumably, if CH<sub>4</sub> were being drained, there would be better data to enable use of tier 2 or even tier 3 methods to make emissions estimates.

#### 3.2.5. UNCONTROLLED COMBUSTION AND BURNING OF COAL DEPOSITS

While emissions from this source may be significant for an individual coal mine, it is unclear as to how significant these emissions may be for an individual country. In some countries where such fires are widespread, the emissions may be very significant. There are no clear methods available at present to systematically measure or precisely estimate the activity data, though where countries have data on amounts of coal burned, the CO<sub>2</sub> should be estimated on the basis of the carbon content of the coal and reported in the relevant subcategory. It is noted that uncontrolled combustion only due to coal exploration activities is considered here. Care should be taken to avoid double counting with fugitive CH<sub>4</sub> and low oxidation CO<sub>2</sub> emissions.

#### 3.2.6. CARBON DIOXIDE CAPTURE AND STORAGE

CCS is an option in the portfolio of actions that could be used to reduce GHG emissions from the continued use of fossil fuels.

These emissions are covered comprehensively, including fugitive losses from CO<sub>2</sub> capture and transport stages (which are estimated using conventional inventory approaches) plus any losses from CO<sub>2</sub> stored underground (estimated by a combination of modelling and measurement techniques, given the amounts injected – which would also be monitored for management purposes). The inventory methods reflect the estimated actual emissions in the year in which they occur. Amounts of

CO<sub>2</sub> captured from combustion of biofuel, and subsequently injected into underground storage are included in the inventory as a negative emission. No distinction is made between any subsequent leakage of this CO<sub>2</sub> and that of CO<sub>2</sub> from fossil sources.

At its simplest, the CCS process is a chain consisting of three major steps: the capture and compression of CO<sub>2</sub> (usually at a large industrial installation), its transport to a storage location and its long-term isolation from the atmosphere. Emissions and reductions should be reported as described below:

- Capture stage: Emissions (and reductions) should be reported under the sector in which capture takes place (e.g. fuel combustion or industrial activities);
- Emissions from plant with CCS = [estimated emissions without capture] – [measured CO<sub>2</sub> captured and transported to validated storage site];
- Transport stage: Emissions should be reported under 1C1;
- Injection stage: Emissions should be reported under 1C2a;
- Storage stage: Emissions should be reported under 1C2b.

### 3.3. OTHER UPDATED INFORMATION

#### 3.3.1. UPDATED DEFAULT EMISSION FACTORS AND OTHER PARAMETERS

Major emission factors and other parameters that have been updated in the 2006 IPCC Guidelines comprise the following:

- **Fuel combustion:** Most default net calorific values, uncertainty ranges, CO<sub>2</sub> emission factors and oxidation factors for fuel combustion have been updated.
- **Fugitive emissions:** Most default emission factors and uncertainty ranges for fugitive emissions (including venting and flaring) from oil and gas operations have been updated.

#### 3.3.2. UPDATED METHODS

Most methods are the same as the Revised 1996 IPCC Guidelines.

# 4. INDUSTRIAL PROCESSES SECTOR




## 4.1. CHANGES IN CATEGORIZATION

Figure 3 illustrates the categorization changes for the industrial processes sector from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines.

Figure 3  
**Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: industrial processes**

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
<b>2 - Industrial Processes</b>	<b>2 - Industrial Processes and Product Use</b>
<b>2.A Mineral Products</b>	<b>2.A Mineral Industry</b>
2.A.1 Cement Production	2.A.1 Cement Production
2.A.2 Lime Production	2.A.2 Lime Production
2.A.3 Limestone and Dolomite Use	2.A.3 Glass Production
	2.A.4 Other Process Uses of Carbonates
	2.A.4.a Ceramics
2.A.4 Soda Ash Production and Use	2.A.4.b Other Uses of Soda Ash
2.A.3 Limestone and Dolomite Use	2.A.4.c Non Metallurgical Magnesia Production
	2.A.4.d Other
2.A.5 Asphalt Roofing	2.A.5 Other
2.A.6 Road Paving with Asphalt	
2.A.7 Other	
<b>2.B Chemical Industry</b>	<b>2.B Chemical Industry</b>
2.B.1 Ammonia Production	2.B.1 Ammonia Production
2.B.2 Nitric Acid Production	2.B.2 Nitric Acid Production
2.B.3 Adipic Acid Production	2.B.3 Adipic Acid Production
	2.B.4 Caprolactam, Glyoxal and Glyoxylic Acid Production
2.B.4 Carbide Production	2.B.5 Carbide Production
	2.B.6 Titanium Dioxide Production
	2.B.7 Soda Ash Production
	2.B.8 Petrochemical and Carbon Black Production
	2.B.8.a Methanol
	2.B.8.b Ethylene
	2.B.8.c Ethylene Dichloride and Vinyl Chloride Monomer
	2.B.8.d Ethylene Oxide
	2.B.8.e Acrylonitrile
	2.B.8.f Carbon Black
	2.B.9 Fluorochemical Production
	2.B.9.a By-product Emissions
	2.B.9.b Fugitive Emissions
	2.B.10 Other
<b>2.E Production of Halocarbons and SF6</b>	<b>2.C Metal Industry</b>
2.E.1 By-product Emissions	2.C.1 Iron and Steel Production
2.E.2 Fugitive Emissions	2.C.2 Ferroalloys Production
2.E.3 Other	2.C.3 Aluminium Production
	2.C.4 Magnesium Production
	2.C.5 Lead Production
	2.C.6 Zinc Production
	2.C.7 Other
<b>2.C Metal Production</b>	<b>2.D Non-Energy Products from Fuels and Solvent Use</b>
2.C.1 Iron and Steel Production	2.D.1 Lubricant Use
2.C.2 Ferroalloys Production	2.D.2 Paraffin Wax Use
2.C.3 Aluminium Production	2.D.3 Solvent Use
2.C.4 SF6 Used in Aluminium and Magnesium Foundries	
	2.D.4 Other
	<b>2.E Electronics Industry</b>
	2.E.1 Integrated Circuit or Semiconductor
	2.E.2 TFT Flat Panel Display
	2.E.3 Photovoltaics
	2.E.4 Heat Transfer Fluid
	<b>2.F Product Uses as Substitutes for Ozone Depleting Substances</b>
	2.F.1 Refrigeration and Air Conditioning
	2.F.1.a Refrigeration and Stationary Air Conditioning
	2.F.1.b Mobile Air Conditioning
	2.F.2 Foam Blowing Agents
	2.F.3 Fire Protection
	2.F.4 Aerosols
	2.F.5 Solvents
	2.F.6 Other Applications
	<b>2.G Other Product Manufacture and Use</b>
	2.G.1 Electrical Equipment
	2.G.1.a Manufacture of Electrical Equipment
	2.G.1.b Use of Electrical Equipment
	2.G.1.c Disposal of Electrical Equipment
	2.G.2 SF6 and PFCs from Other Product Uses
	2.G.2.a Military Applications
	2.G.2.b Accelerators
	2.G.2.c Other
	2.E.5 Other
<b>3 - Solvent and Other Product Use</b>	
<b>3.A Paint Application</b>	
<b>3.B Degreasing and Dry Cleaning</b>	
<b>3.C Chemical Products, Manufacture and Processing</b>	
<b>2.F Consumption of Halocarbons and SF6</b>	
2.F.7 Semiconductor Manufacture	
2.F.1 Refrigeration and Air Conditioning Equipment	
2.F.2 Foam Blowing	
2.F.3 Fire Extinguishers	
2.F.4 Aerosols/ Metered Dose Inhalers	
2.F.5 Solvents	
2.F.6 Other applications using ODS substitutes	
2.F.8 Electrical Equipment	
2.F.9 Other	

Revised 1996 IPCC Guidelines		2006 IPCC Guidelines	
<b>3.D Other</b>		2.G.3 N2O from Product Uses	
3.A.1 Use of N2O for Anaesthesia		2.G.3.a Medical Applications	
3.A.3 N2O from Aerosol Cans		2.G.3.b Propellant for Pressure and Aerosol Products	
3.A.2 N2O from Fire Extinguishers		2.G.3.c Other	
3.A.4 Other Use of N2O			
3.A.5 Other		2.G.4 Other	
<b>2.G Other</b>		<b>2.H Other</b>	
<b>2.D Other Production</b>		2.H.1 Pulp and Paper Industry	
2.D.1 Pulp and Paper		2.H.2 Food and Beverages Industry	
2.D.2 Food and Drink		2.H.3 Other	

	Existing category has been subdivided into 2 or more categories
	New category
	Category that has been eliminated or consolidated

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and 2006 IPCC Guidelines For National Greenhouse Gas Inventories.

## 4.2. CATEGORIES ADDED EXPLICITLY<sup>2</sup>

### 4.2.1. CAPROLACTAM, GLYOXAL AND GLYOXYLIC ACID PRODUCTION

Caprolactam, glyoxal, and glyoxylic acid are potentially important sources of nitrous oxide (N<sub>2</sub>O) emissions in the countries in which the chemicals are produced.

Almost all of the annual production of caprolactam (C<sub>6</sub>H<sub>11</sub>NO) is consumed as the monomer for nylon-6 fibres and plastics, with a substantial proportion of the fibre used in carpet manufacturing. Production of caprolactam can give rise to emissions of N<sub>2</sub>O from the ammonia (NH<sub>3</sub>) oxidation step, emissions of CO<sub>2</sub> from the ammonium carbonate step, emissions of sulphur dioxide (SO<sub>2</sub>) from the ammonium bisulphite step, and emissions of non-methane volatile organic compounds (NMVOCs). Emissions of CO<sub>2</sub>, SO<sub>2</sub> and NMVOCs from the conventional process are unlikely to be significant in well-managed plants. The main GHG to be accounted for from caprolactam production is N<sub>2</sub>O.

Glyoxal (ethanedial) (C<sub>2</sub>H<sub>2</sub>O<sub>2</sub>) is produced from oxidation of acetaldehyde (ethanal) (C<sub>2</sub>H<sub>4</sub>O) with concentrated nitric acid (HNO<sub>3</sub>). Glyoxal can also be produced from catalytic oxidation of ethylene glycol (ethanediol) (CH<sub>2</sub>OHCH<sub>2</sub>OH). Glyoxal is used as a crosslinking agent for vinyl acetate/acrylic resins, disinfectant, gelatine hardening agent, textile finishing agent (permanent-press cotton, rayon fabrics) and wet-resistance additive (paper coatings).

Glyoxylic acid is produced by nitric acid oxidation of glyoxal. Glyoxylic acid is used for the production of synthetic aromas, agrochemicals and pharmaceutical intermediates.

<sup>2</sup> It should be noted that these source/sink categories are not necessarily “new”, because these emissions/removals could have been included in the “Other” categories even when using the Revised 1996 IPCC Guidelines.

#### 4.2.2. TITANIUM DIOXIDE PRODUCTION

Titanium dioxide (TiO<sub>2</sub>) is one of the most commonly used white pigments. The main use is in paint manufacture followed by paper, plastics, rubber, ceramics, fabrics, floor covering, printing ink and other miscellaneous uses. Given the substantial use of the chloride route, CO<sub>2</sub> emissions are likely to be significant and need to be accounted for in GHG inventories.

#### 4.2.3. PETROCHEMICAL AND CARBON BLACK PRODUCTION

The petrochemical industry uses fossil fuels (e.g. natural gas) or petroleum refinery products (e.g. naphtha) as feedstocks. New categories covered by the 2006 IPCC Guidelines are the production of methanol, ethylene and propylene, ethylene dichloride, ethylene oxide, and acrylonitrile. These petrochemicals are addressed in detail because their global production volume and associated GHG emissions are relatively large. However, the chemicals included are not intended to represent the entire petrochemical process industry. There are a number of other petrochemical processes that emit small amounts of GHGs for which specific guidance is not provided (e.g. styrene production).

The 2006 IPCC Guidelines also provide guidance for production of carbon black. Carbon black is not considered to be a petrochemical; however, the carbon black production process uses petrochemical feedstocks. Emissions from carbon black production are smaller than for petrochemical processes but may be significant for certain countries.

#### 4.2.4. LEAD

There are two primary processes for the production of rough lead bullion from lead concentrates. The first type is sintering and smelting, which consists of sequential sintering and smelting steps and constitutes roughly 78 per cent of the primary lead production. The second type is direct smelting, which eliminates the sintering step and constitutes the remaining 22 per cent of primary lead production in the developed world. Carbon dioxide is emitted from both processes but at a different rate.

#### 4.2.5. ZINC

There are three different types of primary zinc production: a metallurgical process called electro-thermic distillation; a pyrometallurgical process involving the use of an imperial smelting furnace; and the electrolytic process, which is a hydrometallurgical technique. The first two processes result in CO<sub>2</sub> emissions. In addition, the Waelz kiln process, which is used to concentrate zinc in flue dusts, sludges, slags and other zinc-containing materials, involves the use of metallurgical coke as a reductant, and also results in non-energy CO<sub>2</sub> emissions.

#### 4.2.6. THIN-FILM-TRANSISTOR FLAT PANEL DISPLAYS, PHOTOVOLTAICS AND HEAT TRANSFER FLUID

Several advanced electronics manufacturing processes utilize fluorinated compounds (FCs) for plasma etching intricate patterns, cleaning reactor chambers and temperature control. The new electronic industry categories explained in the 2006 IPCC Guidelines are thin-film-transistor flat panel display (TFT-FPD) and photovoltaic (PV) manufacturing.

Electronics manufacturers use FCs for temperature control during certain processes. Also known as heat transfer fluids, these FCs are liquids at room temperature and have appreciable vapour pressures. Evaporative losses contribute to the total FC emissions. These evaporative losses occur during cooling of certain process equipment, during testing of packaged semiconductor devices and during vapour phase reflow soldering of electronic components to circuit boards. Because the CO<sub>2</sub> equivalents of each liquid differ, each should be tracked and reported separately.

#### 4.2.7. SULFUR HEXAFLUORIDE AND PERFLUOROCARBONS FROM OTHER PRODUCT USE (MILITARY APPLICATIONS AND ACCELERATORS)

Sulfur hexafluoride (SF<sub>6</sub>) is used as an insulating medium in the radar systems of military reconnaissance planes of the Boeing E-3A type, commonly known as AWACS. The purpose of the SF<sub>6</sub> is to prevent electric flashovers in the hollow conductors of the antenna, in which high voltages of more than 135 kV prevail. When the plane ascends, SF<sub>6</sub> is automatically released from the system and into the atmosphere to maintain the appropriate pressure difference between the system and the outside air. When the plane descends, SF<sub>6</sub> is automatically charged into the system from an SF<sub>6</sub> container on board. Most emissions occur during the pressure-balancing process on ascent, but emissions from system leakage can also occur during other phases of flight or during time on the ground.

There is wide range of military applications using perfluorocarbons (PFCs) or SF<sub>6</sub>. Military electronics are believed to be an important and growing application of PFC heat transfer fluids, which are valued for their stability and dielectric properties. The fluids are used in ground and airborne radar (klystrons), avionics, missile guidance systems, electronic counter measures (ECM), sonar, amphibious assault vehicles, other surveillance aircraft, lasers, the Strategic Defense Initiative (SDI) and stealth aircraft. PFCs may also be used to cool electric motors, particularly in applications where noise reduction is valued, such as in ships and submarines. In all of these cooling applications, the PFC is contained in a closed system, and neither replacement nor replenishment of the PFC liquid appears to be required. Thus, the greatest opportunities for emissions are the manufacture, maintenance and, especially, the disposal of the equipment.

SF<sub>6</sub> is used in high-performance ground and airborne radar systems in their hollow conductors for transmission of high-frequency energy pulses at high voltages from the klystron. Another application of SF<sub>6</sub> is as an oxidant of lithium in a Stored Chemical Energy Propulsion System (SCEPS), such as in naval torpedoes and in infrared decoys. Apparently, these applications of SF<sub>6</sub>, like those of the PFC heat



transfer fluids mentioned above, are generally more or less enclosed, but servicing and testing procedures may lead to emission.

In addition, SF<sub>6</sub> may be emitted as a by-product of the processing of nuclear material for the production of fuel and nuclear warheads. SF<sub>6</sub> is known to be emitted from neutralizing excess fluorine during the production of nuclear fuel for civilian applications.

SF<sub>6</sub> is used in university and research operated particle accelerators as an insulating gas. Typically, high voltage equipment is contained and operated within a vessel filled with SF<sub>6</sub> at a pressure exceeding atmospheric pressure. When the equipment requires maintenance, the SF<sub>6</sub> is transferred into storage tanks. SF<sub>6</sub> losses occur primarily during gas recovery and transfer, when pressure relief valves are actuated, and through slow leaks.

SF<sub>6</sub> is used as an insulating gas in two types of industrial particle accelerators (low and high voltage) and also in medical (cancer therapy) particle accelerators, as is the case for university and research particle accelerators. The emission and charge factors for industrial and medical particle accelerators are different from those of university and research accelerators.

## 4.3. OTHER UPDATED INFORMATION

### 4.3.1. UPDATED DEFAULT EMISSION FACTORS AND OTHER PARAMETERS

Major emission factors and other parameters that have been updated in the 2006 IPCC Guidelines comprise the following:

- Iron and steel production: Updated and more detailed CO<sub>2</sub> emission factors;
- Nitric acid production: Updated N<sub>2</sub>O emission factors;
- Aluminium production: Updated PFC emission factors and uncertainty ranges;
- Ozone depleting substances (ODS) substitutes: Updated fluorinated gas emission factors.

### 4.3.2. UPDATED METHODS

#### ***Non-energy uses of fossil fuels***

Guidance on demarcation with the energy sector has been improved, and emissions from non-energy uses of fossil fuels are now reported under the IPPU sector, rather than in the energy sector. A method has been introduced for checking the completeness of CO<sub>2</sub> emission estimates from the non-energy uses.

#### ***Actual emissions of fluorinated compounds***

The potential emissions approach used as a tier 1 method in the Revised 1996 IPCC Guidelines is no longer considered appropriate, as it does not provide estimates of

true emissions, and is not compatible with higher tiers. The tier 1 methods proposed in this volume are therefore actual emission estimation methods, although these are often based on default activity data where better data are not available. Simplified mass balance approaches have also been proposed in appropriate sectors, such as refrigeration.

### ***Limestone and dolomite consumed***

Emissions should be reported in the industries where these emissions occur; this is particularly relevant for those from the use of limestone, dolomite and other carbonates. For example, CO<sub>2</sub> from limestone used as a flux for iron and steel production was formerly reported under limestone and dolomite use but according to the 2006 IPCC Guidelines, it should be reported under iron and steel production.

### ***Carbon dioxide associated with urea production and use***

Formerly, all these were implicitly included in CO<sub>2</sub> from NH<sub>3</sub> production. CO<sub>2</sub> recovered in the NH<sub>3</sub> production process for urea production should be deducted from CO<sub>2</sub> emissions from NH<sub>3</sub> production. CO<sub>2</sub> emissions from urea use and incineration should be reported in the category where they occur: such as, use of urea-based catalysts (energy sector); urea application to agricultural soils (agriculture, forestry and other land use sector); incineration of urea-based products (waste sector).

## 5. AGRICULTURE SECTOR

### 5.1. CHANGES IN CATEGORIZATION

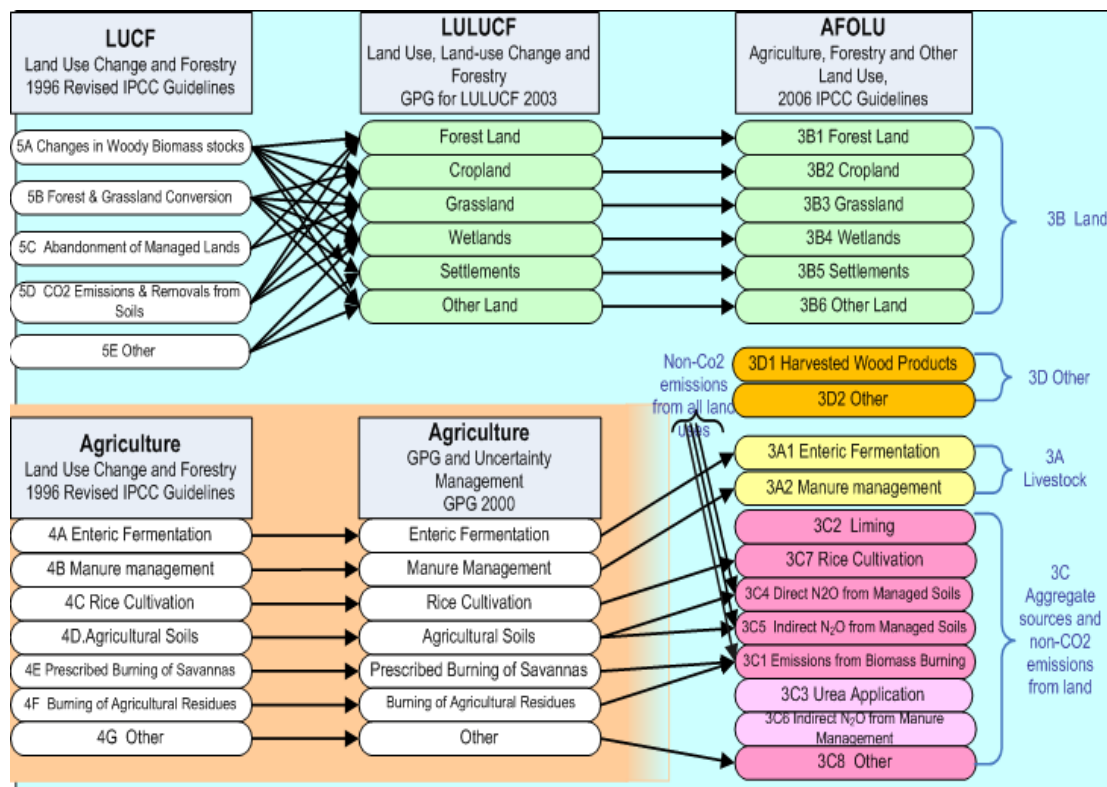
The land use, land-use change and forestry sector in GPG LULUCF is integrated into the AFOLU sector in the 2006 IPCC Guidelines.

The categories under section 3C 'aggregate sources and non-CO<sub>2</sub> emissions from land' of the AFOLU sector is re-organized from non-livestock categories from the agriculture sector and non-CO<sub>2</sub> gases emissions from the LULUCF sector.

The mapping of categories between the 2006 IPCC Guidelines and other IPCC guidance and guidelines (GPG 2000, GPG LULUCF, and the Revised 1996 IPCC Guidelines) is shown in figures 4 and 5.

Figure 4




**Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: agriculture and forestry**



Source: Intergovernmental Panel on Climate Change (IPCC) Task Force on National Greenhouse Gas Inventories (TFI) presentation in a side-event during the thirtieth session of the Subsidiary Body.

Figure 5  
**Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: agriculture**

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
<b>4- Agriculture</b>	<b>3- Agriculture, Forestry, and Other Land Use</b>
<b>4.A Enteric Fermentation</b>	<b>3.A Livestock</b>
4.A.1 Cattle	3.A.1 Enteric Fermentation
Dairy Cattle	3.A.1.a Cattle
Non-Dairy Cattle	3.A.1.a.i Dairy Cows
4.A.2 Buffalo	3.A.1.a.ii Other Cattle
4.A.3 Sheep	3.A.1.b Buffalo
4.A.4 Goats	3.A.1.c Sheep
4.A.5 Camels and Llamas	3.A.1.d Goats
4.A.6 Horses	3.A.1.e Camels
4.A.7 Mules and Asses	3.A.1.f Horses
4.A.8 Swine	3.A.1.g Mules and Asses
4.A.9 Poultry	3.A.1.h Swine
4.A.10 Other	3.A.1.j Other
<b>4.B Manure Management</b>	<b>3.A.2 Manure Management</b>
4.B.1 Cattle	3.A.2.a Cattle
Dairy Cattle	3.A.2.a.i Dairy Cows
Non-Dairy Cattle	3.A.2.a.ii Other Cattle
4.B.2 Buffalo	3.A.2.b Buffalo
4.B.3 Sheep	3.A.2.c Sheep
4.B.4 Goats	3.A.2.d Goats
4.B.5 Camels and Llamas	3.A.2.e Camels
4.B.6 Horses	3.A.2.f Horses
4.B.7 Mules and Asses	3.A.2.g Mules and Asses
4.B.8 Swine	3.A.2.h Swine
4.B.9 Poultry	3.A.2.i Poultry
4.B.10 Anaerobic Lagoons	
4.B.11 Liquid Systems	
4.B.12 Solid Storage and Dry Lot	
4.B.13 Other AWMS	3.A.2.j Other
<b>4.F Field Burning of Agricultural Residues</b>	<b>3.C Aggregate Sources and Non-CO2 Emissions Sources on Land</b>
4.F.1 Cereals	3.C.1 Emissions from Biomass Burning
4.F.2 Pulses	3.C.1.b Biomass Burning in Croplands
4.F.3 Tubers and Roots	
4.F.4 Sugar Cane	
4.F.5 Other	3.C.1.c Biomass Burning in Grasslands
<b>4.E Prescribed Burning of Savannas</b>	3.C.2 Liming
5.(IV) CO2 emissions from agricultural lime application	3.C.3 Urea application
<b>4.D Agricultural Soils</b>	3.C.4 Direct N2O Emissions from Managed Soils
4.D.1 Direct Soil Emissions	3.C.5 Indirect N2O Emissions from Managed Soils
4.D.2 Pasture, Range and Paddock Manure	3.C.6 Indirect N2O Emissions from Manure Management
4.D.3 Indirect Emissions	
<b>4.C Rice Cultivation</b>	3.C.7 Rice Cultivation
4.C.1 Irrigated	
4.C.2 Rainfed	3.C.8 Other
4.C.3 Deep Water	
4.C.4 Other	
4.D.4 Other	
<b>4.G Other</b>	<b>3.D Other</b>

 Existing category has been subdivided into 2 or more categories  
 New category  
 Category that has been eliminated or consolidated

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and 2006 IPCC Guidelines For National Greenhouse Gas Inventories.

## 5.2. CATEGORIES ADDED EXPLICITLY<sup>3</sup>

### 5.2.1. INDIRECT NITROUS OXIDE EMISSIONS FROM MANURE MANAGEMENT

Indirect emissions result from volatile nitrogen (N) losses that occur primarily in the forms of NH<sub>3</sub> and nitrogen oxides (NO<sub>x</sub>). The fraction of excreted organic N that is mineralized to ammonia nitrogen (NH<sub>3</sub>-N) during manure collection and storage depends primarily on time, and to a lesser degree temperature. Simple forms of organic N such as urea (mammals) and uric acid (poultry) are rapidly mineralized to NH<sub>3</sub>-N, which is highly volatile and easily diffused into the surrounding air. N losses begin at the point of excretion in houses and other animal production areas (e.g. milk parlours) and continue through on-site management in storage and treatment systems (i.e. manure management systems).

N is also lost through runoff and leaching into soils from the solid storage of manure at outdoor areas, in feedlots and where animals are grazing in pastures. Pasture losses are considered separately in N<sub>2</sub>O emissions from managed soils, as are emissions of nitrogen compounds from grazing livestock.

### 5.2.2. CARBON DIOXIDE EMISSIONS FROM LIMING

Liming is used to reduce soil acidity and improve plant growth in managed systems, particularly agricultural lands and managed forests. Adding carbonates to soils in the form of lime (e.g. calcic limestone (CaCO<sub>3</sub>), or dolomite (CaMg(CO<sub>3</sub>)<sub>2</sub>)) leads to CO<sub>2</sub> emissions as the carbonate limes dissolve and release bicarbonate (2HCO<sub>3</sub><sup>-</sup>), which evolves into CO<sub>2</sub> and water (H<sub>2</sub>O).

This category was calculated in the LULUCF sector in the good practice guidance.

### 5.2.3. CARBON DIOXIDE EMISSIONS FROM UREA FERTILIZATION

Adding urea to soils during fertilization leads to a loss of CO<sub>2</sub> that was fixed in the industrial production process. Urea (CO(NH<sub>2</sub>)<sub>2</sub>) is converted into ammonium (NH<sub>4</sub><sup>+</sup>), hydroxyl ion (OH<sup>-</sup>), and bicarbonate (HCO<sub>3</sub><sup>-</sup>), in the presence of water and urease enzymes. Similar to the soil reaction following addition of lime, bicarbonate that is formed evolves into CO<sub>2</sub> and water. This source category is included because the CO<sub>2</sub> removal from the atmosphere during urea manufacturing is estimated in the IPPU sector.

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<sup>3</sup> It should be noted that these source/sink categories are not necessarily “new”, because these emissions/removals could have been included in the “Other” categories even when using the Revised 1996 IPCC Guidelines.

#### 5.2.4. NITROUS OXIDE FROM NITROGEN MINERALIZATION ASSOCIATED WITH LOSS OF SOIL ORGANIC MATTER RESULTING FROM CHANGE OF LAND USE OR MANAGEMENT OF MINERAL SOILS (SUBCATEGORY IN DIRECT NITROUS OXIDE EMISSIONS FROM MANAGED SOILS)

N<sub>2</sub>O is emitted from mineralization of N in soil organic matter following cultivation or land-use change on mineral soils (e.g. forest land/grassland/settlements converted to cropland). This is a subcategory in direct N<sub>2</sub>O emissions from managed soils.

This category was calculated in the LULUCF sector in the good practice guidance.

The amount of N from mineralization is used as activity data for the N<sub>2</sub>O emissions from leaching and runoff in indirect N<sub>2</sub>O emissions from managed soils.

### 5.3. OTHER UPDATED INFORMATION

#### 5.3.1. UPDATED DEFAULT EMISSION FACTORS AND OTHER PARAMETERS

##### ***Methane emissions from enteric fermentation***

Tier 1 emission factors for cattle are updated, and tier 1 emission factors for deer and alpacas are added. The methane conversion factors for cattle and sheep to use for tier 2 method are updated.

##### ***Methane emissions from manure management***

Tier 1 emission factors are updated, and tier 1 emission factors for deer, reindeer, rabbits and fur-bearing animals are added. Emission factors for cattle, swine and buffalo are listed by the annual average temperature for the climate zone where the livestock manure is managed. The amount of volatile solids (VS), the maximum amount of methane able to be produced from that manure (Bo), the methane conversion factor (MCF) and the fraction of manure management system (MS) for tier 2 method are updated.

##### ***N<sub>2</sub>O emissions from manure management***

The annual average N excretion per head (N<sub>ex</sub>) and the emission factors for tier 1 method are updated.

##### ***N<sub>2</sub>O emissions from managed soils (direct and indirect)***

The emission factors for direct N<sub>2</sub>O emissions and indirect N<sub>2</sub>O emissions (leaching and runoff only) are updated.

### 5.3.2. UPDATED METHODS

#### ***Livestock population and feed characterization***

The estimation method and parameters of calculating gross energy is updated.

#### ***Methane emissions from rice cultivation***

The estimation method for CH<sub>4</sub> emissions from rice cultivation is updated. Though a seasonally integrated emission factor was used in GPG 2000, a daily emission factor is used in the 2006 IPCC Guidelines.

#### ***CH<sub>4</sub> and N<sub>2</sub>O emissions from biomass burning***

The agricultural residue burning is integrated with the savannah burning into biomass burning in the 2006 IPCC Guidelines. The estimation method for CH<sub>4</sub> and N<sub>2</sub>O emissions from biomass burning is updated from both the agricultural residue burning and the savannah burning. The area burned, the mass of fuel available for combustion and combustion factor are used in new equation.

#### ***N<sub>2</sub>O emissions from managed soils (direct and indirect)***

The estimation method for N<sub>2</sub>O emissions from crop residues is updated. The new estimation method considers both aboveground and below-ground residues. This subcategory includes the amount of N of N-fixing crops, returned to soils annually, though N<sub>2</sub>O emissions from N-fixing crops was one subcategory in GPG 2000. The amount of N from crop residues is added as activity data for the N<sub>2</sub>O emissions from leaching and runoff in indirect N<sub>2</sub>O emissions from managed soils in the 2006 IPCC Guidelines.

## 6. LAND-USE CHANGE AND FORESTRY SECTOR

### 6.1. CHANGES IN CATEGORIZATION

The land use, land-use change and forestry sector in the GPG LULUCF is merged with the agriculture sector to form the agriculture, forestry and other land use (AFOLU) sector in the 2006 IPCC Guidelines.

The scope of section 3.B 'Land' of the AFOLU sector is basically equivalent to the carbon stock change estimations for the six land use categories provided in the GPG LULUCF. The categories under section 3.C 'Aggregate sources and non-CO<sub>2</sub> emissions from land' of the AFOLU sector comprises non-livestock categories from the agriculture sector and non-CO<sub>2</sub> gas emissions from the LULUCF sector. Section 3.D.1 'Harvested wood products' comes from the appendix section from the GPG LULUCF.

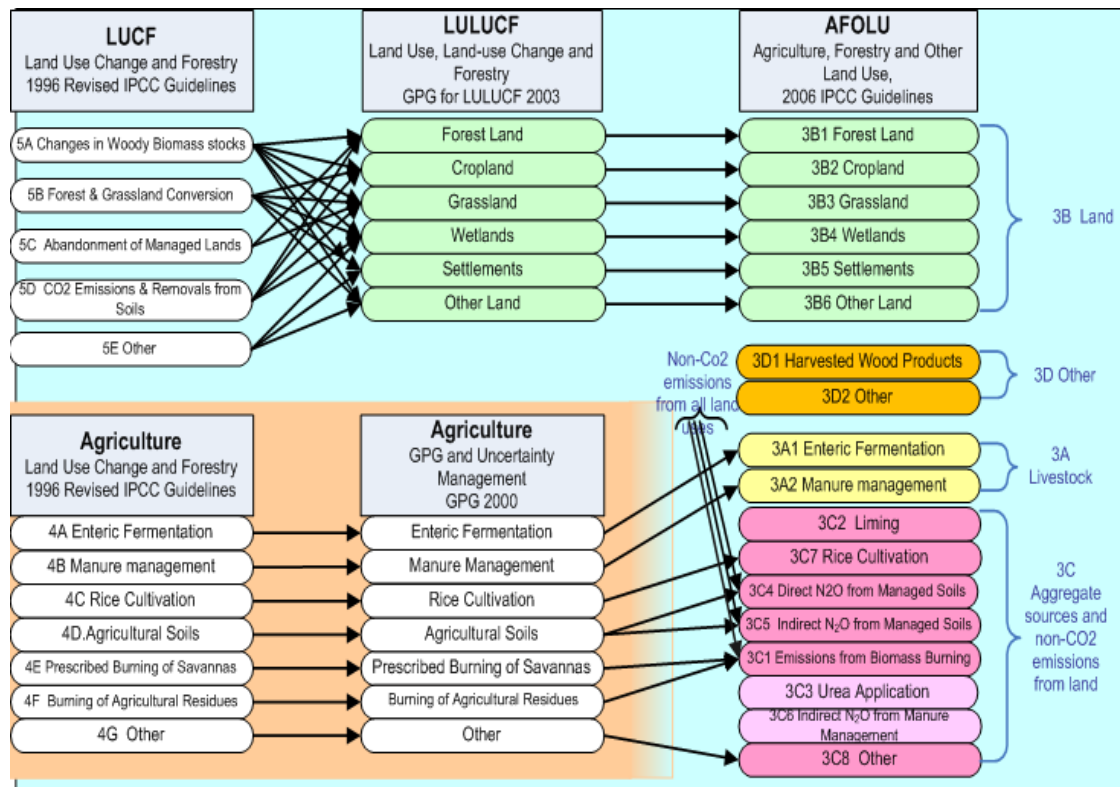
In general, the basic estimation methodologies of the LULUCF sector in the GPG LULUCF are retained in the AFOLU sector in the 2006 IPCC Guidelines. This means that the 2006 IPCC Guidelines are based on the six land use classifications with two subcategories of remaining land and converted land, carbon pool based estimation, and focusing all emissions and removals from managed land. These are only some of the differences which should be remembered by the team of technical experts when a Party applies the 2006 IPCC Guidelines.

The mapping of categories between the 2006 IPCC Guidelines and other IPCC guidance and guidelines (GPG 2000, GPG LULUCF, and the Revised 1996 IPCC Guidelines) is shown in figures 6 and 7.



Figure 6

**Categorization of the changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: forestry**



Source: Intergovernmental Panel on Climate Change (IPCC) Task Force on National Greenhouse Gas Inventories (TFI) presentation in a side-event during the thirtieth session of the Subsidiary Body.

Figure 7

**Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: land use change and forestry**

GPG 2000, GPG LULUCF	2006 IPCC Guidelines
<b>5 - Land Use Change and Forestry</b>	<b>3.B Land</b>
<b>5.A Forest Land</b>	3.B.1 Forest Land
5.A.1 Forest Land remaining Forest Land	3.B.1.a Forest Land Remaining Forest Land
5.A.2 Land converted to Forest Land	3.B.1.b Land Converted to Forest Land
<b>5.B Cropland</b>	3.B.2 Cropland
5.B.1 Cropland remaining Cropland	3.B.2.a Cropland Remaining Cropland
5.B.2 Land converted to Cropland	3.B.2.b Land Converted to Cropland
<b>5.C Grassland</b>	3.B.3 Grassland
5.C.1 Grassland remaining Grassland	3.B.3.a Grassland Remaining Grassland
5.C.2 Land converted to Grassland	3.B.3.b Land Converted to Grassland
<b>5.D Wetlands</b>	3.B.4 Wetlands
5.D.1 Wetlands remaining Wetlands (optional)	3.B.4.a Wetlands Remaining Wetlands
5.D.2 Land converted to Wetlands	3.B.4.b Land Converted to Wetlands
<b>5.E Settlements</b>	3.B.5 Settlements
5.E.1 Settlements remaining Settlements (optional)	3.B.5.a Settlements Remaining Settlements
5.E.2 Land converted to Settlements	3.B.5.b Land Converted to Settlements
<b>5.F Other Land</b>	3.B.6 Other Land
5.F.1 Other Land remaining Other Land	3.B.6.a Other Land Remaining Other Land
5.F.2 Land converted to Other Land	3.B.6.b Land Converted to Other Land
<b>Non Carbon stock change emissions</b>	<b>3.C Aggregate sources and non-CO2 emissions sources on land</b>
5.(V) Biomass burning	3.C.1 GHG emissions from biomass burning
5.(IV) CO2 emissions from agricultural lime application	3.C.2 Liming
5.(I) Direct N2O emissions from N fertilization of FL and Other	3.C.4 Direct N2O Emissions from Managed Soils
5.(II) Non-CO2 emissions from drainage of soils and wetlands	3.C.5 Indirect N2O Emissions from Managed Soils (other than cropland & grassland)
5.(III) N2O emissions from disturbance associated with land-use conversion to cropland	
	<b>3.D Other</b>
<b>5.G Other</b>	3.D.1 Harvested Wood Products
Harvested Wood Products (optional)	3.D.2 Other
Other	

- Existing category has been subdivided into 2 or more categories
- New category (including new mandatory reporting category)
- Category that has been eliminated or consolidated

Source: IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, Good Practice Guidance for Land Use, Land-Use Change and Forestry and 2006 IPCC Guidelines For National Greenhouse Gas Inventories.

## 6.2. CATEGORIES ADDED EXPLICITLY<sup>4</sup>

### 6.2.1. HARVESTED WOOD PRODUCTS

The GPG LULUCF contains some information on harvested wood products (HWP) in the appendices. The 2006 IPCC Guidelines include HWP as a separate category (reporting remains optional). There are three accounting approaches for estimating carbon stock changes in HWP which differ in the allocation between wood producing and consuming countries, and processes (atmospheric fluxes or stock changes). Currently, there is no decision about which approach a Party should use; so, any of the three accounting approaches can be used for developing a national GHG inventory. The 2006 IPCC Guidelines do not select any of the proposed accounting approaches, but provide guidance on the estimation of the five underlying parameters and how to combine these for each accounting approach.

<sup>4</sup> It should be noted that these source/sink categories are not necessarily “new”, because these emissions/removals could have been included in the “Other” categories even when using the Revised 1996 IPCC Guidelines.

## 6.2.2. WETLANDS REMAINING WETLANDS

Methodologies under organic soils managed for peat extraction and flooded land remaining flooded land under wetlands remaining wetlands were covered in the appendix of the GPG LULUCF and treated as an optional reporting category. In the 2006 IPCC Guidelines, CO<sub>2</sub> and N<sub>2</sub>O emissions from managed peat land under wetlands remaining wetlands have been covered in the main text. However, the scope of wetlands and GHG gases covered in the 2006 IPCC Guidelines is not comprehensive, as shown in table 2.

Table 2  
Sections of the 2006 IPCC Guidelines addressing major greenhouse gas emissions from managed wetlands

TABLE 7.1 SECTIONS ADDRESSING MAJOR GREENHOUSE GAS EMISSIONS FROM MANAGED WETLANDS		
Land-use category/GHG	Peatlands	Flooded Land
Wetlands Remaining Wetlands		
CO <sub>2</sub>	Section 7.2.1.1	No Guidance <sup>1</sup>
CH <sub>4</sub>	No Guidance <sup>2</sup>	Appendix 3
N <sub>2</sub> O	Section 7.2.1.2	No Guidance <sup>3</sup>
Lands Converted to Wetlands		
CO <sub>2</sub>	Section 7.2.2.1	Section 7.3.2.1 and Appendix 2
CH <sub>4</sub>	No Guidance <sup>2</sup>	Appendix 3
N <sub>2</sub> O	Section 7.2.2.2	No Guidance <sup>3</sup>
NOTES:		
<sup>1</sup> CO <sub>2</sub> emissions from <i>Flooded land Remaining Flooded land</i> are covered by carbon stock change estimates of land uses and land-use change (e.g., soils) upstream of the Flooded Land.		
<sup>2</sup> Methane emission from peatlands is negligible after drainage during conversion and peat extraction.		
<sup>3</sup> N <sub>2</sub> O emissions from Flooded Land are included in the estimates of indirect N <sub>2</sub> O from agricultural or other run-off, and waste water.		

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, p. 7.5.

## 6.2.3. SETTLEMENTS REMAINING SETTLEMENTS

The GPG LULUCF provides methodologies about aboveground biomass in trees in settlement areas in the appendix (reporting is optional). In the 2006 IPCC Guidelines, the methodologies have been expanded to include five carbon pools and have been moved to the main text, where they are treated as a mandatory reporting category, like any other land-use category. Regarding the methods for estimating emissions and removals from the biomass, the old tier 1 method has become tier 2 in the 2006 IPCC Guidelines, and a new tier 1 (carbon stock change of the biomass is regarded as zero) has been introduced.

#### 6.2.4. INDIRECT NITROUS OXIDE EMISSIONS FROM NON-AGRICULTURE LAND USES

The GPG 2000 and GPG LULUCF address both direct and indirect N<sub>2</sub>O emissions from cropland, but only direct N<sub>2</sub>O emissions from land-use management and changes from some other land uses, such as forest land and grassland. The 2006 IPCC Guidelines include guidance on direct and indirect N<sub>2</sub>O emissions due to the management and land-use change from “all” land-based sources.

#### 6.2.5. NITROUS OXIDE EMISSIONS FROM MINERALIZATION ASSOCIATED WITH LAND-USE CHANGES AND MANAGEMENT CHANGES

The GPG LULUCF has already provided the methodology for estimating N<sub>2</sub>O emissions from disturbance associated with land-use conversion to cropland. The 2006 IPCC Guidelines have expanded the scope of this methodology which now covers all land-use and management changes where soil carbon stock changes occur. In the tier 3 method, users are allowed to include immobilization of N<sub>2</sub>O (nitrogen sequestration) associated with gain of soil carbon stock.

### 6.3. OTHER UPDATED INFORMATION

#### 6.3.1. UPDATED DEFAULT EMISSION FACTORS AND OTHER PARAMETERS

##### ***Biomass conversion and expansion factor (BCEF)***

In the calculation of emissions from forest land, a new parameter of the BCEF has been introduced, and the default parameters are provided for BCEF<sub>S</sub> (for merchantable growing stock), BCEF<sub>I</sub> (for net annual increment) and BCEF<sub>R</sub> (for wood removals). BCEF is a product of the biomass expansion factor (BEF) and wood density (D), which were parameters used in the GPG LULUCF.

##### ***CO<sub>2</sub> EF for cultivated organic soil***

Updated information on the CO<sub>2</sub> EF for boreal/cool temperate cropland and perennial woody crop in cropland are provided in the 2006 IPCC Guidelines.

#### 6.3.2. UPDATED METHODS

##### ***Name of methods used in carbon stock changes***

Although the methods have not changed, their names have evolved from “default method” to “Gain-Loss method”, and from “stock change method” to “Stock-Difference method”.

### ***Treatment of fire (loss and recovery)***

In both the GPG LULUCF and the 2006 IPCC Guidelines, GHGs emitted from both the wildfires and prescribed burning on managed lands should be included (CO<sub>2</sub> and non-CO<sub>2</sub> for forestland, and only non-CO<sub>2</sub> for grassland, etc.). In the GPG LULUCF, CO<sub>2</sub> emissions from wildfires and prescribed burnings on managed forests need not be reported if the removals due to subsequent regrowth are not captured in the estimation methods. However, in the 2006 IPCC Guidelines, CO<sub>2</sub> fluxes from wildfires and prescribed burnings on all managed land have to be reported together with the subsequent regrowth. This is because the loss process and regrowth process are not always equivalent due to non-maintenance of soil fertility, etc., and the 2006 IPCC Guidelines capture the actual annual emissions more accurately.

### ***Carbon stock changes in dead organic matter in cropland and grassland***

The tier 1 method (assume this to be zero) was provided in the GPG LULUCF. The 2006 IPCC Guidelines provide a higher tier method and allow the estimate of dead organic matter carbon stock changes occurring in cropland and grassland.

### ***Carbon stock changes in dead organic matter and soil in land converted to settlements***

The land converted to settlements category in the GPG LULUCF focused on the methodology for living biomass only. The 2006 IPCC Guidelines have expanded the scope of carbon pools and provide methods for carbon stock changes in dead organic matter and soil organic matter for land converted to settlements.

### ***CO<sub>2</sub> emissions from cultivated or drained organic soil***

The scope of this emission source in the GPG LULUCF covers forest land, cropland and grassland. In the 2006 IPCC Guidelines, other land-use categories are also covered in the calculation.

### ***Biomass burning***

There are two methods for estimating non-CO<sub>2</sub> emissions from biomass burning in the GPG LULUCF, the approach using the total carbon released as an activity data, and the approach using the area burned as an activity data. In the 2006 IPCC Guidelines, the former method was removed.

### ***Fuelwood removal***

In the calculation of biomass loss in the 2006 IPCC Guidelines, the fuelwood volume removed from the forest site is divided into two components. The first component is removing parts of the living tree such as tops and branches. The second component is gathering whole trees from dead wood and logging slash. It is good practice, according to the 2006 IPCC Guidelines, to estimate these two components separately if possible.

## 7. WASTE SECTOR

### 7.1. CHANGES IN CATEGORIZATION

The categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines are illustrated in figure 8.

Figure 8  
**Categorization changes from the Revised 1996 IPCC Guidelines to the 2006 IPCC Guidelines: waste**

Revised 1996 IPCC Guidelines	2006 IPCC Guidelines
<b>6- Waste</b>	<b>4- Waste</b>
<b>6.A Solid Waste Disposal on Land</b>	<b>4.A Solid Waste Disposal</b>
6.A.1 Managed Waste Disposal on Land	4.A.1 Managed Waste Disposal Sites
6.A.2 Unmanaged Waste Disposal Sites	4.A.2 Unmanaged Waste Disposal Sites
6.A.3 Other	4.A.3 Uncategorized Waste Disposal Sites
	<b>4.B Biological Treatment of Solid Waste</b>
<b>6.C Waste Incineration</b>	<b>4.C Incineration and Open Burning of Waste</b>
	4.C.1 Waste Incineration
	4.C.2 Open Burning of Waste
<b>6.B Waste water Handling</b>	<b>4.D Wastewater Treatment and Discharge</b>
6.B.2 Domestic and Commercial Wastewater	4.D.1 Domestic Wastewater Treatment and Discharge
6.B.1 Industrial Waste water	4.D.2 Industrial Wastewater Treatment and Discharge
6.B.3 Other	
<b>6.D Other</b>	<b>4.E Other</b>

	Existing category has been subdivided into 2 or more categories
	New category
	Category that has been eliminated or consolidated

Source: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and 2006 IPCC Guidelines For National Greenhouse Gas Inventories.

### 7.2. CATEGORIES ADDED EXPLICITLY<sup>5</sup>

#### 7.2.1. UNCATEGORIZED WASTE DISPOSAL SITES

If countries cannot categorize their solid waste disposal sites (SWDSs) into four categories of managed and unmanaged SWDSs, emissions should be reported under this category. The 2006 IPCC Guidelines provide methane correction factors (MCF) and oxidation factors (OX) for this category.

<sup>5</sup> It should be noted that these source/sink categories are not necessarily “new”, because these emissions/removals could have been included in the “Other” categories even when using the Revised 1996 IPCC Guidelines.

## 7.2.2. BIOLOGICAL TREATMENT OF SOLID WASTE

Composting and anaerobic digestion of organic waste, such as food waste, garden (yard) and park waste and sludge, is common both in developed and developing countries. The advantages of biological treatment include: reduced volume in the waste material, stabilization of the waste, destruction of pathogens in the waste material and production of biogas for energy use. The end products of the biological treatment can, depending on its quality, be recycled as fertilizer and soil amendment, or be disposed of in SWDSs.

Anaerobic treatment is usually linked with CH<sub>4</sub> recovery and combustion for energy, and thus the GHG emissions from the process should be reported in the energy sector. Anaerobic sludge treatment at wastewater treatment facilities is addressed in wastewater treatment and discharge, and emissions should be reported under the categories of wastewater. However, when sludge from wastewater treatment is transferred to an anaerobic facility which is co-digesting sludge with solid municipal or other waste, any related CH<sub>4</sub> and N<sub>2</sub>O emissions should be reported under this category, biological treatment of solid waste. Where these gases are used for energy, then associated emissions should be reported in the energy sector.

Composting is an aerobic process and a large fraction of the degradable organic carbon in the waste material is converted into CO<sub>2</sub>. CH<sub>4</sub> is formed in anaerobic sections of the compost, but it is oxidized there to a large extent. The estimated CH<sub>4</sub> released into the atmosphere ranges from less than 1 per cent to a few per cent of the initial carbon content in the material.

Composting can also produce emissions of N<sub>2</sub>O. The range of the estimated emissions varies from less than 0.5 per cent to 5 per cent of the initial N content of the material. Poorly functioning composts are likely to produce more both of CH<sub>4</sub> and N<sub>2</sub>O.

## 7.3. OTHER UPDATED INFORMATION

### 7.3.1. UPDATED DEFAULT EMISSION FACTORS AND OTHER PARAMETERS

#### ***Solid waste disposal***

Managed solid waste disposal sites are classified into anaerobic and semi-aerobic. Default values for default methane generation rate (k) and half-life (t<sub>1/2</sub>) were provided by waste type and climatic zone.

#### ***Wastewater***

The 2006 IPCC Guidelines provide default methane conversion (MCF) values, biochemical oxygen demand (BOD) values and ranges in domestic wastewater, values for urbanization and degree of utilization of treatment, and discharge pathways or methods for each income group for domestic wastewater. The 2006 IPCC Guidelines also contain examples of wastewater generation, ranges, chemical oxygen demand (COD), and COD ranges for industrial wastewater.

### ***Waste incineration (more guidance is provided in the 2006 IPCC Guidelines)***

Default data for CO<sub>2</sub> emission factors is updated and the level of detail for emission factors is improved. Default CH<sub>4</sub> emission factors for municipal solid waste (MSW), and default N<sub>2</sub>O emission factors for MSW and industrial waste are provided in the 2006 IPCC Guidelines. Default CH<sub>4</sub> and N<sub>2</sub>O emission factors for open burning are provided.

## **7.3.2. UPDATED METHODS**

### ***Solid waste disposal***

The Revised 1996 IPCC Guidelines and the GPG 2000 described two methods for estimating CH<sub>4</sub> emissions from SWDSs: the mass balance method (tier 1) and the first order decay (FOD) method (tier 2). The mass balance approach in the earlier guidance is based on the assumption that all potential CH<sub>4</sub> is released in the year when the waste is disposed of to a SWDS. However, the degradable organic component in waste disposed of at landfills decays slowly throughout a few decades, during which a significant amount of CH<sub>4</sub> and CO<sub>2</sub> are emitted. The overall decomposition can be approximated by FOD reaction. The FOD method requires data for historical disposals of waste over a time period of 3–5 half-lives to achieve accurate emission estimates.

In the 2006 IPCC Guidelines, the use of the mass balance method is strongly discouraged as it produces results that are not comparable with the FOD method, which produces more accurate estimates of annual emissions. In place of the mass balance method, the 2006 IPCC Guidelines provides a tier 1 version of the FOD method, including a simple spreadsheet model with step-by-step guidance and improved default data. With this guidance, all countries should be able to implement the FOD method.

### ***Wastewater***

Factors for urbanization and degree of utilization of treatment/discharge pathway or system for each income group for domestic wastewater have been introduced for estimation of CH<sub>4</sub> emissions. A method for estimation of N<sub>2</sub>O emissions from domestic wastewater effluent discharged into aquatic environments is provided.