

2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

OVERVIEW

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1 INTRODUCTION

The *2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines)* provide methodologies for estimating national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases. The *2006 IPCC Guidelines* were prepared in response to an invitation by the Parties to the UNFCCC. They may assist Parties in fulfilling their commitments under the UNFCCC on reporting on inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, as agreed by the Parties. The *2006 IPCC Guidelines* are in five volumes. Volume 1 describes the basic steps in inventory development and offers the general guidance in greenhouse gas emissions and removals estimates based on the authors' understanding of accumulated experiences of countries over the period since the late 1980s, when national greenhouse gas inventories started to appear in significant numbers. Volumes 2 to 5 offer the guidance for estimates in different sectors of economy.

The IPCC has previously developed the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*¹ (*1996 IPCC Guidelines*), together with the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*² (*GPG2000*) and the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*³ (*GPG-LULUCF*). Taken together, they provide internationally agreed⁴ methodologies that countries currently use to estimate greenhouse gas inventories to report to the United Nations Framework Convention on Climate Change (UNFCCC). The three-volume *1996 IPCC Guidelines* define the coverage of the national inventory in terms of gases and categories of emissions by sources and removals by sinks, and the *GPG2000* and *GPG-LULUCF* provide additional guidance on choice of estimation methodology, improvements of the methods, as well as advice on cross-cutting issues, including estimation of uncertainties, time series consistency and quality assurance and quality control.

At its seventeenth session, held in New Delhi in 2002, the Subsidiary Body for Scientific and Technological Advice (SBSTA) under the UNFCCC invited the IPCC to revise the *1996 IPCC Guidelines*, taking into consideration the relevant work under the Convention and the Kyoto Protocol⁵, with the aim of completing the work by early 2006.

In response to the UNFCCC's invitation, the IPCC, at its 20th session in Paris, in February 2003, initiated a process that led to an agreement at its 21st session (in Vienna, November 2003) of Terms of Reference, Table of Contents and a Workplan⁶ for the *2006 IPCC Guidelines*. The Workplan aimed to complete the task in time for adoption and acceptance at the 25th session of the IPCC, in April 2006. The Terms of Reference specified that the revision should be based on, *inter alia*, the *1996 IPCC Guidelines*, *GPG2000*, *GPG-LULUCF*, and experiences from the UNFCCC technical inventory review process.

¹ Intergovernmental Panel on Climate Change (IPCC) (1997). Houghton J.T., Meira Filho L.G., Lim B., Tréanton K., Mamaty I., Bonduki Y., Griggs D.J. and Callander B.A. (Eds). *Revised 1996 IPCC Guidelines for National Greenhouse Inventories*. IPCC/OECD/IEA, Paris, France.

² Intergovernmental Panel on Climate Change (IPCC) (2000). Penman J., Kruger D., Galbally I., Hiraishi T., Nyenzi B., Emmanuel S., Buendia L., Hoppaus R., Martinsen T., Meijer J., Miwa K., and Tanabe K. (Eds). *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. IPCC/OECD/IEA/IGES, Hayama, Japan.

³ Intergovernmental Panel on Climate Change (IPCC) (2003). Penman J., Gytarsky M., Hiraishi T., Krug, T., Kruger D., Pipatti R., Buendia L., Miwa K., Ngara T., Tanabe K., and Wagner F (Eds). *Good Practice Guidance for Land Use, land-Use Change and Forestry* IPCC/IGES, Hayama, Japan.

⁴ See the Report of the Fourth Session of the Subsidiary Body for Scientific and Technological Advice (FCCC/SBSTA/1996/20), paragraph 30; decisions 2/CP.3 and 3/CP.5 (UNFCCC reporting guidelines for preparation of national communications by Parties included in Annex I to the Convention, part I: UNFCCC reporting guidelines on annual inventories), decision 18/CP.8, revising the guidelines adopted under decisions 3/CP.5, and 17/CP.8 adopting improved guidelines for the preparation of national communications from Parties not included in Annex I to the Convention, and subsequent decisions 13/CP.9 and Draft Decision /CP.10.

⁵ Including, *inter alia*, work by the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation, and by the Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention, and the technical review of greenhouse gas inventories of Annex I Parties.

⁶ The Terms of Reference, Table of Contents and Work plan can be found at <http://www.ipcc-nggip.iges.or.jp/>.

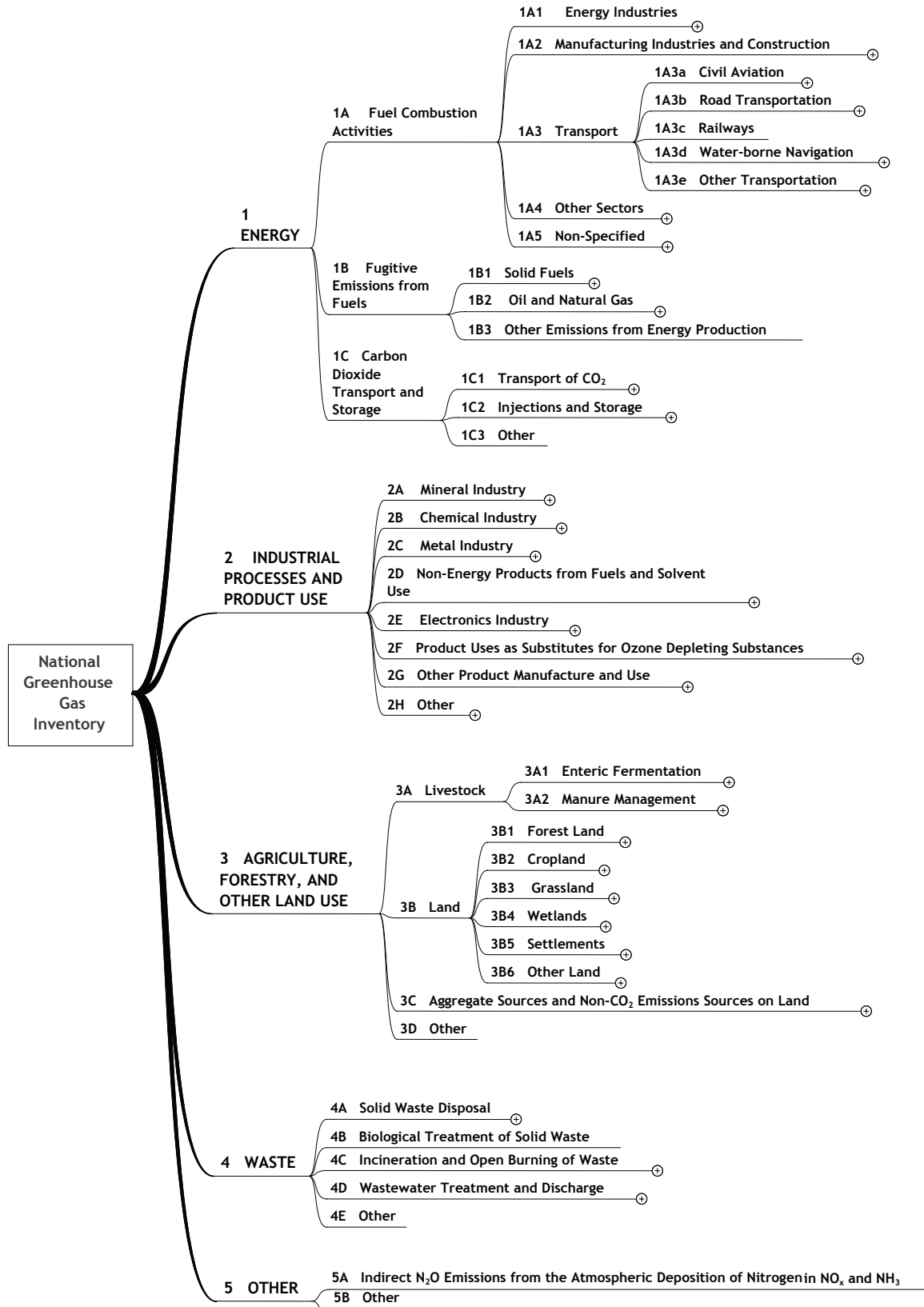
2 COVERAGE OF THE GUIDELINES

Table 1 shows the contents of the five volumes that make up the *2006 IPCC Guidelines*. Estimation methods are provided for the gases shown in Tables 2 and 3, and cover the categories shown in Figure 1. Reporting is described in Chapter 8 of Volume 1. Coverage is complete for all greenhouse gases not covered by the Montreal Protocol, for which the IPCC, at the time of writing, provided a global warming potential (GWP)⁷.

TABLE 1 CONTENTS OF 2006 GUIDELINES	
Volumes	Chapters
1 - General Guidance and Reporting	<ol style="list-style-type: none"> 1. Introduction to the 2006 Guidelines 2. Approaches to Data Collection 3. Uncertainties 4. Methodological Choice and Identification of Key Categories 5. Time Series Consistency 6. Quality Assurance/Quality Control and Verification 7. Precursors and Indirect Emissions 8. Reporting Guidance and Tables
2 - Energy	<ol style="list-style-type: none"> 1. Introduction 2. Stationary Combustion 3. Mobile Combustion 4. Fugitive Emissions 5. CO₂ Transport, Injection and Geological Storage 6. Reference Approach
3 - Industrial Processes and Product Use	<ol style="list-style-type: none"> 1. Introduction 2. Mineral Industry Emissions 3. Chemical Industry Emissions 4. Metal Industry Emissions 5. Non-Energy Products from Fuels and Solvent Use 6. Electronics Industry Emissions 7. Emissions of Fluorinated Substitutes for Ozone Depleting Substances 8. Other Product Manufacture and Use
4 - Agriculture, Forestry and Other Land Use	<ol style="list-style-type: none"> 1. Introduction 2. Generic Methodologies Applicable to Multiple Land-use Categories 3. Consistent Representation of Lands 4. Forest Land 5. Cropland 6. Grassland 7. Wetlands 8. Settlements 9. Other Land 10. Emissions from Livestock and Manure Management 11. N₂O Emissions from Managed Soils, and CO₂ Emissions from Lime and Urea Application 12. Harvested Wood Products
5 - Waste	<ol style="list-style-type: none"> 1. Introduction 2. Waste Generation, Composition and Management Data 3. Solid Waste Disposal 4. Biological Treatment of Solid Waste 5. Incineration and Open Burning of Waste 6. Wastewater Treatment and Discharge

⁷ Climate Change 2001: The Scientific Basis Contribution of Working Group I to the Third Assessment Report of the IPCC, (TAR), (ISBN 0521 80767 6), Section 6.12.2, Direct GWPs.

Figure 1 Main categories of emissions by sources and removals by sinks



Volume 3 of the *2006 IPCC Guidelines* also provides estimation methods and/or emission factors for some direct greenhouse gases not covered by the Montreal Protocol for which GWP values were not available from the IPCC at the time of writing (Table 3). These gases are sometimes used as substitutes for gases included in Table 2, for industrial and product applications. Until GWP values are made available from the IPCC, countries will be unable to incorporate these gases in *key category* analysis (see Section 3 below) or include them in national total GWP weighted emissions. However, optionally, countries may wish to provide estimates of these greenhouse gases in mass units, using the methods provided in the *2006 IPCC Guidelines*. Reporting tables are provided for this purpose.

Name	Symbol
Carbon Dioxide	CO ₂
Methane	CH ₄
Nitrous Oxide	N ₂ O
Hydrofluorocarbons	HFCs (e.g., HFC-23 (CHF ₃), HFC-134a (CH ₂ FCF ₃), HFC-152a (CH ₃ CHF ₂))
Perfluorocarbons	PFCs (CF ₄ , C ₂ F ₆ , C ₃ F ₈ , C ₄ F ₁₀ , c-C ₄ F ₈ , C ₅ F ₁₂ , C ₆ F ₁₄)
Sulphur Hexafluoride	SF ₆
Nitrogen Trifluoride	NF ₃
Trifluoromethyl Sulphur Pentafluoride	SF ₅ CF ₃
Halogenated Ethers	e.g., C ₄ F ₉ OC ₂ H ₅ , CHF ₂ OCF ₂ OC ₂ F ₄ OCHF ₂ , CHF ₂ OCF ₂ OCHF ₂
Other halocarbons	e.g., CF ₃ I, CH ₂ Br ₂ , CHCl ₃ , CH ₃ Cl, CH ₂ Cl ₂ ⁹

C ₃ F ₇ C(O)C ₂ F ₅ ¹⁰
C ₇ F ₁₆
C ₄ F ₆
C ₅ F ₈
c-C ₄ F ₈ O

The *2006 IPCC Guidelines* contain links to information on methods used under other agreements and conventions¹¹, for the estimation of emissions of tropospheric precursors which may be used to supplement the reporting of emissions and removals of greenhouse gases for which methods are provided here.

⁸ Third Assessment Report of the IPCC. See also footnote 7.

⁹ For these gases, emissions can be estimated following the methods described in Section 3.10.2 of Volume 3 if necessary data are available, and then reported under sub-category 2B10 "Other".

¹⁰ This gas is traded as NovectTM612 which is a fluorinated ketone produced by 3M (Milbrath, 2002).

¹¹ See, for example, Volume 1 Sections 7.1 and 7.2, where inventory developers are referred to the material developed by the Task Force on Emission Inventories and Projections of the UNECE's Convention on Long-Range Transboundary Air Pollution for the purpose of estimating emissions of sulphur dioxide (SO₂); carbon monoxide (CO); oxides of nitrogen (NO_x); ammonia (NH₃) and non-methane volatile organic compounds (NMVOCs).

3 APPROACH TO DEVELOPING THE GUIDELINES

The *2006 IPCC Guidelines* are an evolutionary development starting from the *1996 IPCC Guidelines*, *GPG2000* 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, new scientific information, and the results of the UNFCCC review process. The most significant changes occur in Volume 4, which consolidates the approach to Land Use, Land-Use Change and Forestry (LULUCF) in *GPG-LULUCF* and the Agriculture sector in *GPG2000* into a single Agriculture, Forestry and Other Land Use (AFOLU) Volume. This, and other important developments and changes, are summarised in Section 5 below.

The *2006 IPCC Guidelines* retain the definition of *good practice* that was introduced with *GPG2000*. This definition has gained general acceptance amongst countries as the basis for inventory development. According to this definition, national inventories of anthropogenic greenhouse gas 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*.

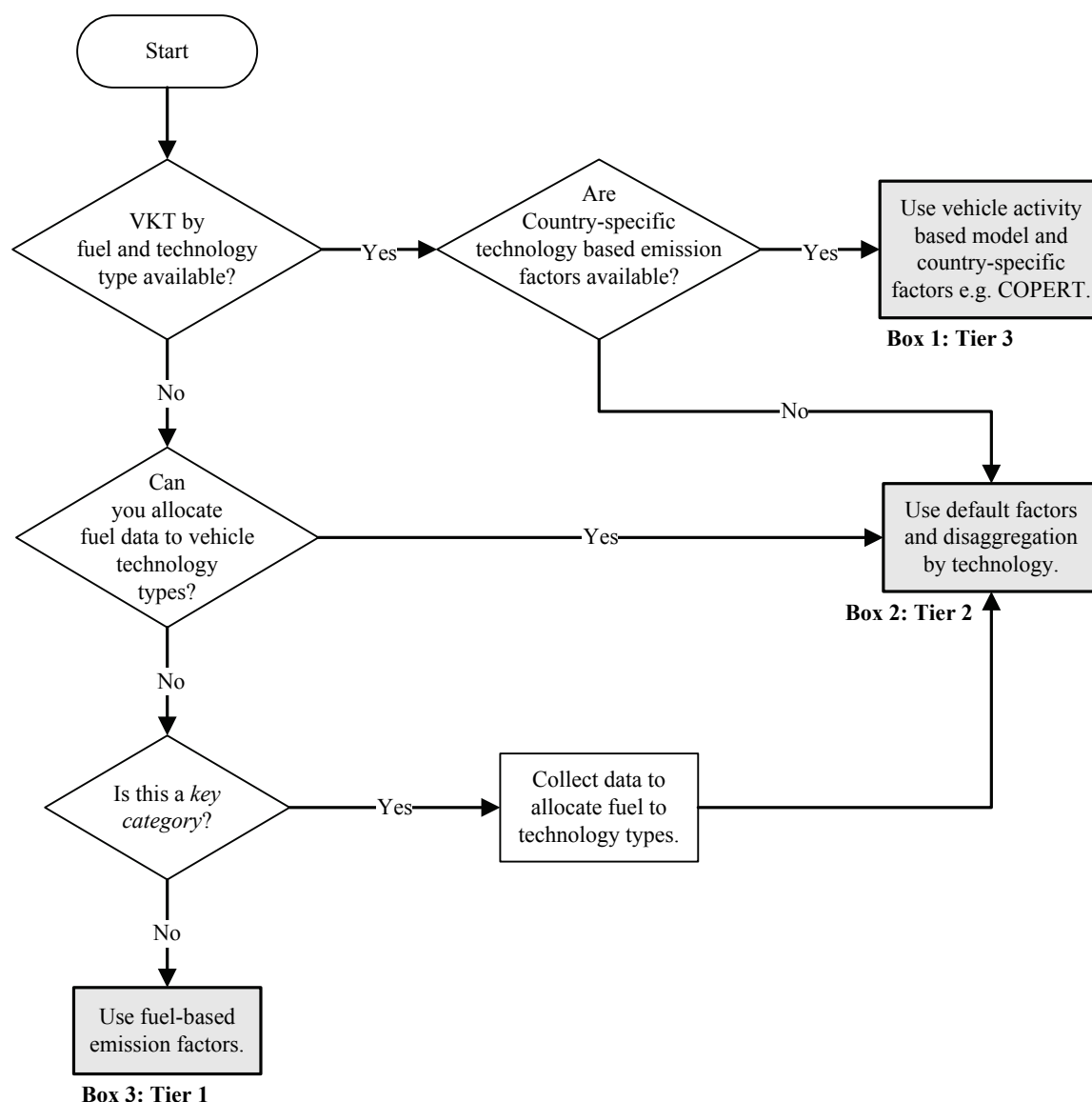
These requirements are intended to ensure that estimates of emissions by sources and removals by sinks, even if uncertain, are *bona fide* estimates, in the sense of not containing any biases that could have been identified and eliminated, and that uncertainties have been reduced as far as practicable, given national circumstances. Estimates of this type are presumably the best attainable, given current scientific knowledge and available resources.

The *2006 IPCC Guidelines* generally provide advice on estimation methods at three levels of detail, from tier 1 (the default method) to tier 3 (the most detailed method). The advice consists of mathematical specification of the methods, information on emission factors or other parameters to use in generating the estimates, and sources of activity data to estimate the overall level of net emissions (emission by sources minus removals by sinks). Properly implemented, all tiers are intended to provide unbiased estimates, and accuracy and precision should, in general, improve from tier 1 to tier 3. The provision of different tiers enables inventory compilers to use methods consistent with their resources and to focus their efforts on those categories of emissions and removals that contribute most significantly to national emission totals and trends.

The *2006 IPCC Guidelines* apply the tiered approach by means of *decision trees* (see the example in Figure 2). A decision tree guides selection of the tier to use for estimating the category under consideration, given national circumstances. National circumstances include the availability of required data, and contribution made by the category to total national emissions and removals and to their trend over time. The most important categories, in terms of total national emissions and the trend, are called *key categories*¹². Decision trees generally require tier 2 or tier 3 methods for *key categories*. The *2006 IPCC Guidelines* provide for exceptions to this, where evidence demonstrates that the expense of data collection would significantly jeopardize the resources available for estimating other *key categories*.

The *2006 IPCC Guidelines* also provide advice on; i) ensuring data collection is representative and time series are consistent, ii) estimation of uncertainties at the category level, and for the inventory as a whole, iii) guidance on quality assurance and quality control procedures to provide cross-checks during inventory compilation, and iv) information to be documented, archived and reported to facilitate review and assessment of inventory estimates. Reporting tables and worksheets for tier 1 methods are provided. The use of tiered methodologies and decision trees and the cross cutting advice ensure that the finite resources available for inventory development and updating are deployed most effectively, and that the inventory is checked and reported in a transparent manner.

¹² In the *GPG2000* and *GPG-LULUCF* these were called *key sources*, or *key categories* where there could be removals.

Figure 2 Example Decision Tree (for CH₄ and N₂O from Road Transport)

4 STRUCTURE OF THE GUIDELINES

The structure of the *2006 IPCC Guidelines* improves upon the structure of the *1996 IPCC Guidelines*, *GPG2000* and *GPG-LULUCF* in two respects.

Firstly, whereas a user of the *1996 IPCC Guidelines*, *GPG2000* and *GPG-LULUCF* may need to cross reference between four or five volumes¹³ to make an emission or removal estimate, the *2006 IPCC Guidelines* may require cross referencing between two volumes: Volume 1 (General Guidance and Reporting), and the relevant sectoral volume (one of Volume 2 (Energy), Volume 3 (Industrial Processes and Product Use), Volume 4 (Agriculture, Forestry and Other Land Use), and Volume 5 (Waste)). This represents a considerable simplification.

Secondly, the *2006 IPCC Guidelines* present Agriculture, Forestry and Other Land Use in a single volume, rather than two volumes comprising Agriculture, on the one hand, and Land-use Change and Forestry on the other. This allows for better integration of information on the pattern of land use and should facilitate more consistent use of activity data (for example, fertilizer application), that affects both agriculture and other land uses, thus reducing or avoiding the possibilities for double counting or omission.

¹³ That is, three volumes of the *IPCC 1996 Guidelines* plus at least one of *GPG2000* or *GPG-LULUCF*.

The *2006 IPCC Guidelines* retain the standardised layout of methodological advice at the category level that was introduced in *GPG2000* and was maintained in *GPG-LULUCF*. Table 4 shows the general structure used for each category. Any user familiar with *GPG2000* and *GPG-LULUCF* should be able to shift to the *2006 IPCC Guidelines* without difficulty.

TABLE 4	
GENERAL STRUCTURE OF SECTORAL GUIDANCE CHAPTERS	
•	Methodological Issues <ul style="list-style-type: none"> ○ Choice of Method, including decision trees and definition of tiers. ○ Choice of Emission Factor ○ Choice of Activity Data ○ Completeness ○ Developing a Consistent Time Series
•	Uncertainty Assessment <ul style="list-style-type: none"> ○ Emission Factor Uncertainties ○ Activity Data Uncertainties
•	Quality Assurance/Quality Control, Reporting and Documentation
•	Worksheets

The previous IPCC inventory guidance has been reviewed and, where needed, clarified and expanded to improve its user friendliness. Across all the volumes, some additional categories have been identified and included. The guidance focuses on inventory methodologies rather than on scientific discussions of the background material, for which references are provided.

5 SPECIFIC DEVELOPMENTS IN THE 2006 IPCC GUIDELINES

The *2006 IPCC Guidelines* are based on a thorough scientific review and a structural enhancement of the IPCC's inventory methodology across all categories, including the following specific developments:

Volume 1 (General Guidance and Reporting)

- *Introductory advice:* A new section has been included, providing for an overview of greenhouse gas inventories and the steps needed to prepare an inventory for the first time.
- *Extended advice on data collection:* The *2006 IPCC Guidelines* introduce systematic cross-cutting advice on data collection from existing sources and by new activities, including design of measurement programmes.
- *Key category analysis:* General principles and guidance are provided. In the *2006 IPCC Guidelines*, the integration of Agriculture and LULUCF into the AFOLU volume has been addressed, and key category analysis is better integrated across emission and removal categories.

Volume 2 (Energy)

- *Treatment of CO₂ capture and storage:* These emissions are covered comprehensively, including fugitive losses from CO₂ capture and transport stages (which are estimated using conventional inventory approaches) plus any losses from carbon dioxide 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. The inventory methods for geological CO₂ capture, transport and storage (CCS) provided in Volume 2 are consistent with the IPCC Special Report on Carbon Dioxide Capture and Storage (2005). Amounts of CO₂ 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 CO₂ and that of CO₂ from fossil sources.
- *Methane from abandoned coal mines:* A methodology for estimating these emissions is included in the *2006 IPCC Guidelines* for the first time.

Volume 3 (Industrial Processes and Product Use)

- *New categories and new gases:* The 2006 IPCC Guidelines have been expanded to include more manufacturing sectors and product uses identified as sources of greenhouse gases. These include production of lead, zinc, titanium dioxide, petrochemicals, and liquid crystal display (LCD) manufacturing. Additional greenhouse gases identified in the IPCC Third Assessment Report are also included where anthropogenic sources have been identified. These gases include nitrogen trifluoride (NF₃), trifluoromethyl sulphur pentafluoride (SF₅CF₃), and halogenated ethers.
- *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 Industrial Processes and Product Use, rather than in Energy. A method has been introduced for checking the completeness of carbon dioxide emission estimates from the non-energy uses.
- *Actual emissions of fluorinated compounds:* The potential emissions approach used as a tier 1 method in the 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.

Volume 4 (Agriculture, Forestry and Other Land Use)

- *Integration between agriculture and land use, land-use change and forestry:* 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.
- *Managed land is used in these guidelines as a proxy for identifying anthropogenic emissions by sources and removals by sinks.* In most AFOLU sectors anthropogenic GHG emissions by source and removals by sinks are defined as those occurring on *managed land*. The use of managed land as a proxy for anthropogenic effects was adopted in the GPG-LULUCF. The preponderance of anthropogenic effects occurs on managed lands and, from a practical standpoint, the information needed for inventory estimation is largely confined to managed lands.
- *Consolidation of previously optional categories:* Emissions by sources and removals by sinks associated with all fires on managed land are now estimated, removing the previous optional distinction between wildfires and prescribed burning. This is consistent with the concept of managed land as a proxy for identifying anthropogenic emissions by sources and removals by sinks, as discussed above. Wildfires and other disturbances on unmanaged land cannot, in general, be associated to an anthropogenic or natural cause, and hence are not included in the 2006 IPCC Guidelines, unless the disturbance is followed by a land-use change. In this case, the land affected by disturbance is considered to be managed, and all the greenhouse gas emissions by sources and removals by sinks associated to the fire and other events are now estimated, irrespective of whether of a natural origin or not. Carbon dioxide emissions and removals associated with terrestrial carbon stocks in settlements and managed wetlands, which were previously optional, have been incorporated into the main guidance.
- *Harvested wood products (HWP):* The 2006 IPCC Guidelines provide detailed methods that can be used to include HWP in greenhouse gas inventories using any of the approaches that are currently under discussion within the UNFCCC process.
- *Emissions from managed wetlands:* The 2006 IPCC Guidelines now contain methods to estimate CO₂ emissions due to land use change in wetlands. However, due to limited availability of scientific information, methods for CH₄ emissions are contained in an Appendix – Basis for future methodological development.

Volume 5 (Waste)

- *Revised methodology for methane from landfills:* The previous Tier 1 method, based on the maximum potential release of methane in the year of placement, has been replaced by a simple first order decay model that provides the option to use data available from the UN and other sources. This approach includes regional and country-specific defaults on waste generation, composition and management, and provides a consistent basis for estimating greenhouse gas emissions across all tiers. This gives a more accurate time series for estimated emissions and should avoid the situation in which usage of landfill gas apparently exceeds the amount generated in a particular year.
- *Carbon accumulation in landfills:* This is provided as an output from the decay models, and can be relevant for the estimation of HWP in AFOLU.

- *Biological treatment and open burning of waste:* Guidance on estimation of emissions from composting and biogas facilities has been included to ensure a more complete coverage of sources.

Relevant to all volumes

- *CO₂ resulting from the emissions of other gases:* The *2006 IPCC Guidelines* estimate carbon emissions in terms of the species which are emitted. Most of the carbon emitted as these non-CO₂ species eventually oxidises to CO₂ in the atmosphere; and this amount can be estimated from the emissions estimates of the non-CO₂ gases. In some cases the emissions of these non-CO₂ gases contain very small amounts of carbon compared to the CO₂ estimate and it may be more accurate to base the CO₂ estimate on the total carbon. See Volume 1 Section 7.2.1.5 for an approach to estimating these inputs of CO₂ to the atmosphere. Examples are fossil fuel combustion (where the emission factor is derived from the carbon content of the fuel) and a few IPPU sectors where the carbon mass balance can be estimated much better than individual gases.
- *Treatment of nitrogen (N) deposition:* The *GPG2000* lists sources of anthropogenic nitrogen deposition that subsequently give rise to anthropogenic emissions of nitrous oxide (N₂O), but provides estimation methods only for a subset of these, associated with agricultural sources of ammonia (NH₃) and nitrogen oxides (NO_x). The *2006 IPCC Guidelines* extend this approach to all significant sources of N deposition, including agriculture, industrial and combustion sources, with the ultimate N₂O emission attributed to the country responsible for the nitrogen originally emitted.
- *Relationship to entity- or project level estimates:* The Guidelines are intended to help prepare national inventories of emissions by sources and removals by sinks. Nonetheless, the Guidelines can also be relevant for estimating actual emissions or removals at the entity or project level.