WMO

Intergovernmental Panel on Climate Change

UNEP

2006 IPCC Guidelines for National Greenhouse Gas Inventories

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IPCC National Greenhouse Gas Inventories Programme

IGES

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Foreword

Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) co-established in 1988 the Intergovernmental Panel on Climate Change (IPCC). One of the IPCC's activities is to support the UN Framework Convention on Climate Change (UNFCCC) through its work on methodologies for National Greenhouse Gas Inventories.

This report is the culmination of three years of work by the IPCC National Greenhouse Gas Inventories Programme, to update its own previous guidance on National Greenhouse Gas Emission Inventories. The task was started in response to an invitation made at the seventeenth session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC, held in New Delhi in 2002. At the time, the IPCC was invited to revise the *1996 IPCC Guidelines*, taking into consideration the relevant work made under the Convention and the Kyoto Protocol[1], with the aim to complete this task by early 2006.

In response to this invitation by the UNFCCC, the IPCC initiated a process at its 20th session (Paris, February 2003) that led to an agreement at its 21st session (Vienna, November 2003) on the Terms of Reference, Table of Contents and a Workplan[2] for the *2006 IPCC Guidelines*. The Workplan aimed to complete the task in time for its acceptance and adoption at the 25th session of the IPCC, to be held in April 2006.

The 1996 guidelines comprised the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*[3], together with the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*[4] and the *Good Practice Guidance for Land Use, Land-Use Change and Forestry*[5]. The *2006 Guidelines* have built upon this body of work in an evolutionary manner to ensure that the transition from the previous guidelines to these new ones will be as straightforward as possible. These new guidelines include new sources and gases as well as updates to the previously published methods whenever scientific and technical knowledge have improved since the previous guidelines were issued.

The development of these guidelines has depended on the expertise, knowledge and co-operation of the Coordinating Lead Authors, Lead Authors and Contributing Authors – the contribution over 250 experts worldwide. We wish to thank these authors for their commitment, time and efforts in preparing this report throughout all the drafting and reviewing stages of the IPCC process. As indicated, this report has built upon the work of the previous IPCC inventory reports as well as on reports of the inventory experts' experiences in using the IPCC inventory guidelines without which the task would have been much more demanding and we are pleased to acknowledge our debt with all those who contributed to these reports.

The steering group, consisting of IPCC TFI Co-Chairs Taka Hiraishi (Japan) and Thelma Krug (Brazil) together with Michael Gytarsky (Russian Federation), William Irving (USA) and Jim Penman (UK) has guided the development of these guidelines, ensuring consistency across all the volumes and continuity with the earlier IPCC inventory reports. We would therefore wish to thank them for their considerable efforts in leading and guiding the report preparation.

Authors and experts meetings were held in Oslo (Norway); Le Morne (Mauritius); Washington (USA); Arusha (Tanzania); Ottawa (Canada); Manila (The Philippines); Moscow (Russian Federation); and Sydney (Australia). We would therefore like to thank the host countries and agencies for organizing these meetings. We would also

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1 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.

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

3 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.

4 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.

5 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., Wagner F., *Good Practice Guidance for Land Use, land-Use Change and Forestry* IPCC/IGES, Hayama, Japan

like to thank all governments that supported authors and reviewers, for without their contributions, the production of this report might not have been possible.

Two reviews of these guidelines were made in 2005. The first, an expert review, produced over 6000 comments, while the second, a combined governmental and expert review, resulted in an additional 8600 comments. The efforts of the reviewers and their comments have contributed greatly to the quality of the final report and we wish to thank them accordingly. Furthermore, the review editors have ensured the appropriate consideration of all the comments received, so we would also like to thank them for their work.

In addition, the NGGIP Technical Support Unit (TSU Head: Simon Eggleston; Programme officers: Leandro Buendia, Kyoko Miwa, Todd Ngara and Kiyoto Tanabe; Administrative Assistant: Ayako Hongo; Project Secretary: Masako Abe; and IT Officer: Toru Matsumoto) has provided guidance and assistance as well as technical and organisational support for the project. They worked extensively with the authors especially in the editing of the various drafts and preparation of the final version, and we wish to congratulate them for their exemplary work. We would also like to express our gratitude to the Government of Japan, for its generous support for the TSU, without which this report might not have been completed.

We would also like to thank the IPCC Secretariat (Jian Liu, Rudie Bourgeois, Annie Courtin, and Joelle Fernandez) for their assistance and support in enabling this project to meet its tight deadlines.

Finally we would like to thank IPCC Chair Rajendra Pachauri, IPCC Secretary Renate Christ and the Task Force Bureau: the TFI Co-Chairs and Soobaraj Nayroo Sok Appadu (Mauritius), Dari N. Al-Ajmi (Kuwait), Ian Carruthers (Australia), Sergio Gonzalez-Martineaux (Chile), Art Jaques (Canada), Jamidu H.Y. Katima (Tanzania), Sadeddin Kherfan (Syria), Dina Kruger (USA), Kirit Parikh (India), Jim Penman (UK, since 2006), Helen Plume (New Zealand), Audun Rosland (Norway until 2005) and Freddy Tejada (Bolivia) for their support.

Michel Jarraud

Secretary-General
World Meteorological Organisation

Achim Steiner

Executive Director
United Nations Environment Programme

Preface

These *2006 IPCC Guidelines for National Greenhouse Gas Inventories* build on the previous Revised 1996 IPCC Guidelines and the subsequent Good Practice reports in an evolutionary manner to ensure that moving from the previous guidelines to these new guidelines is as straightforward as possible. These new guidelines cover new sources and gases as well as updates to previously published methods where technical and scientific knowledge have improved.

This guidance assists countries in compiling complete, national inventories of greenhouse gases. The guidance has been structured so that any country, regardless of experience or resources, should be able to produce reliable estimates of their emissions and removals of these gases. In particular, default values of the various parameters and emission factors required are supplied for all sectors, so that, at its simplest, a country needs only supply national activity data. The approach also allows countries with more information and resources to use more detailed country-specific methodologies while retaining compatibility, comparability and consistency between countries. The guidance also integrates and improves earlier guidance on good practice in inventory compilation so that the final estimates are neither over- nor under-estimates as far as can be judged and uncertainties are reduced as far as possible.

Guidance is also provided to identify areas of the inventory whose improvement would most benefit the inventory overall. Hence limited resources can be focused on those areas most in need of improvement to produce the best practical inventory.

The IPCC also manages the *IPCC Emission Factor Database* (EFDB). The EFDB was launched in 2002, and is regularly updated as a resource for inventory compilers to use to assist them by providing a repository of emission factors and other relevant parameters that may be suitable for use in more country-specific methodologies.

The 2006 Guidelines are the latest step in the IPCC development of inventory guidelines for national estimates of greenhouse gases. In the opinion of the authors, they provide the best, widely applicable default methodologies and, as such, are suitable for global use in compiling national greenhouse gas inventories. They may also be of use in more narrowly-defined project based estimates, although here they should be used with caution to ensure they correctly include just the emissions and removals from within the system boundaries.

We would also like to thank all the authors (over 250) as well as reviewers, review editors, the steering group and the TFB for their contributions and experience. We would also like to thank all the governments who contributed by hosting meetings (Oslo, Norway; Le Morne, Mauritius; Washington, USA; Arusha, Tanzania; Ottawa, Canada; Manila, The Philippines; Moscow, Russian Federation; and Sydney, Australia) as well as those who supported authors and other contributors. Finally we would like to express our gratitude to the NGGIP TSU and the IPCC Secretariat for their invaluable support throughout the entire process of drafting and producing these guidelines.

Taka Hiraishi (Japan)
IPCC TFI Co-Chair

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2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

OVERVIEW

Authors

Jim Penman (UK), Michael Gytarsky (Russia), Taka Hiraishi (Japan), William Irving (USA), and Thelma Krug (Brazil)

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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 agreed[4] 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 Protocol[5], 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 Workplan[6] 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.

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[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

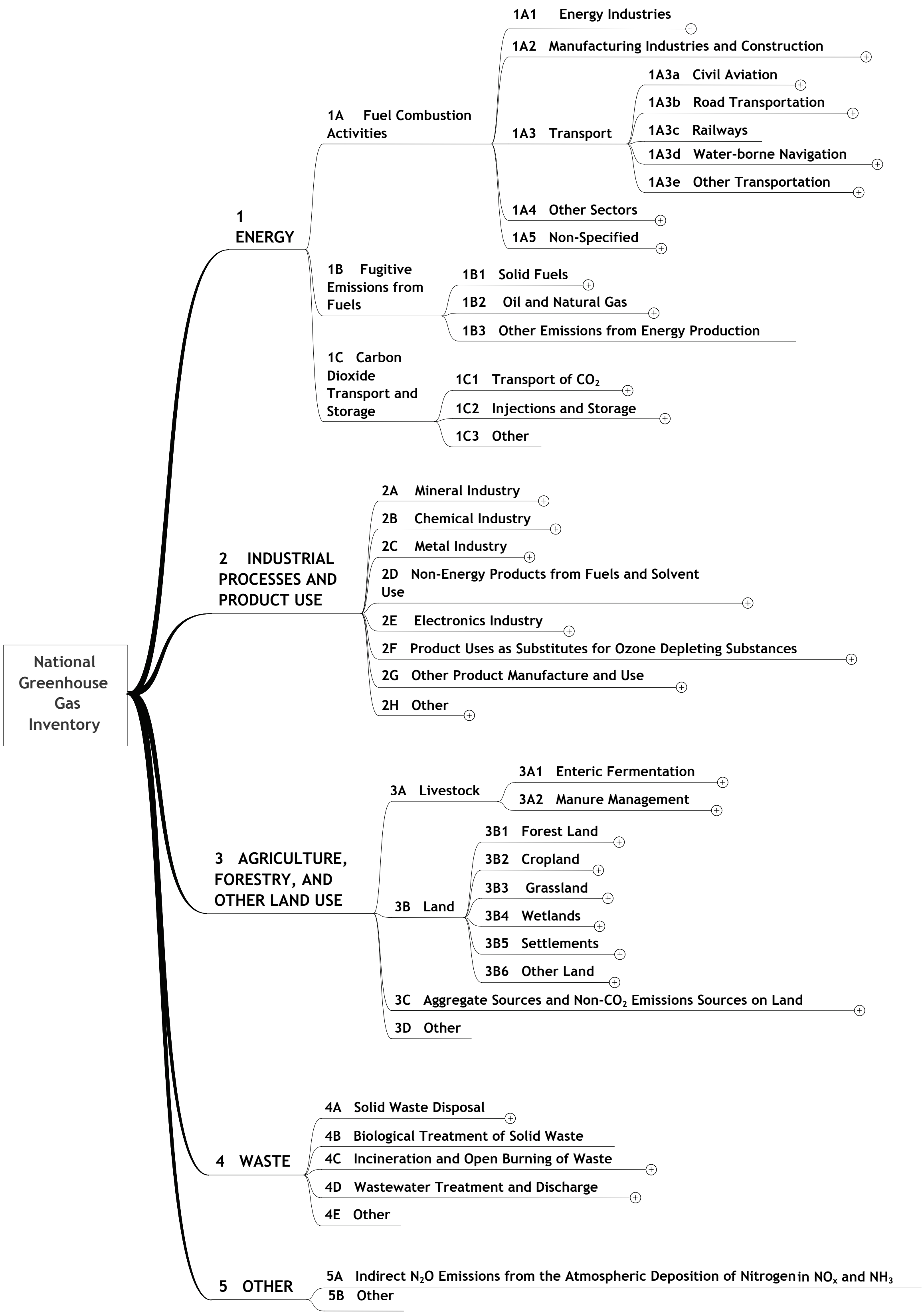
Table 1 shows the contents of the five volumes that make up the *2006 IPCC Guidelines.* Estimation methods are provided for the gases shown in Tables 2 and 3, and cover the categories shown in Figure 1. Reporting is described in Chapter 8 of Volume 1. Coverage is complete for all greenhouse gases not 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	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	1. Introduction 2. Stationary Combustion 3. Mobile Combustion 4. Fugitive Emissions 5. CO_2 Transport, Injection and Geological Storage 6. Reference Approach
3 - Industrial Processes and Product Use	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	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. N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application 12. Harvested Wood Products
5 - Waste	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.

TABLE 2
GASES FOR WHICH GWP VALUES ARE AVAILABLE IN THE TAR[8]

Name	Symbol
Carbon Dioxide	CO_2
Methane	CH_4
Nitrous Oxide	N_2O
Hydrofluorocarbons	HFCs (e.g., HFC-23 (CHF_3), HFC-134a (CH_2FCF_3), HFC-152a (CH_3CHF_2))
Perfluorocarbons	PFCs (CF_4, C_2F_6, C_3F_8, C_4F_{10}, c-C_4F_8, C_5F_{12}, C_6F_{14})
Sulphur Hexafluoride	SF_6
Nitrogen Trifluoride	NF_3
Trifluoromethyl Sulphur Pentafluoride	SF_5CF_3
Halogenated Ethers	e.g., $C_4F_9OC_2H_5$, $CHF_2OCF_2OC_2F_4OCHF_2$, $CHF_2OCF_2OCHF_2$
Other halocarbons	e.g., CF_3I, CH_2Br_2, $CHCl_3$, CH_3Cl, CH_2Cl_2[9]

TABLE 3
ADDITIONAL GASES FOR WHICH GWP VALUES ARE NOT AVAILABLE IN THE TAR

$C_3F_7C(O)C_2F_5$[10]
C_7F_{16}
C_4F_6
C_5F_8
c-C_4F_8O

The *2006 IPCC Guidelines* contain links to information on methods used under other agreements and conventions[11], 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 Novec™612 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 (SO_2); carbon monoxide (CO); oxides of nitrogen (NO_x); ammonia (NH_3) 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.

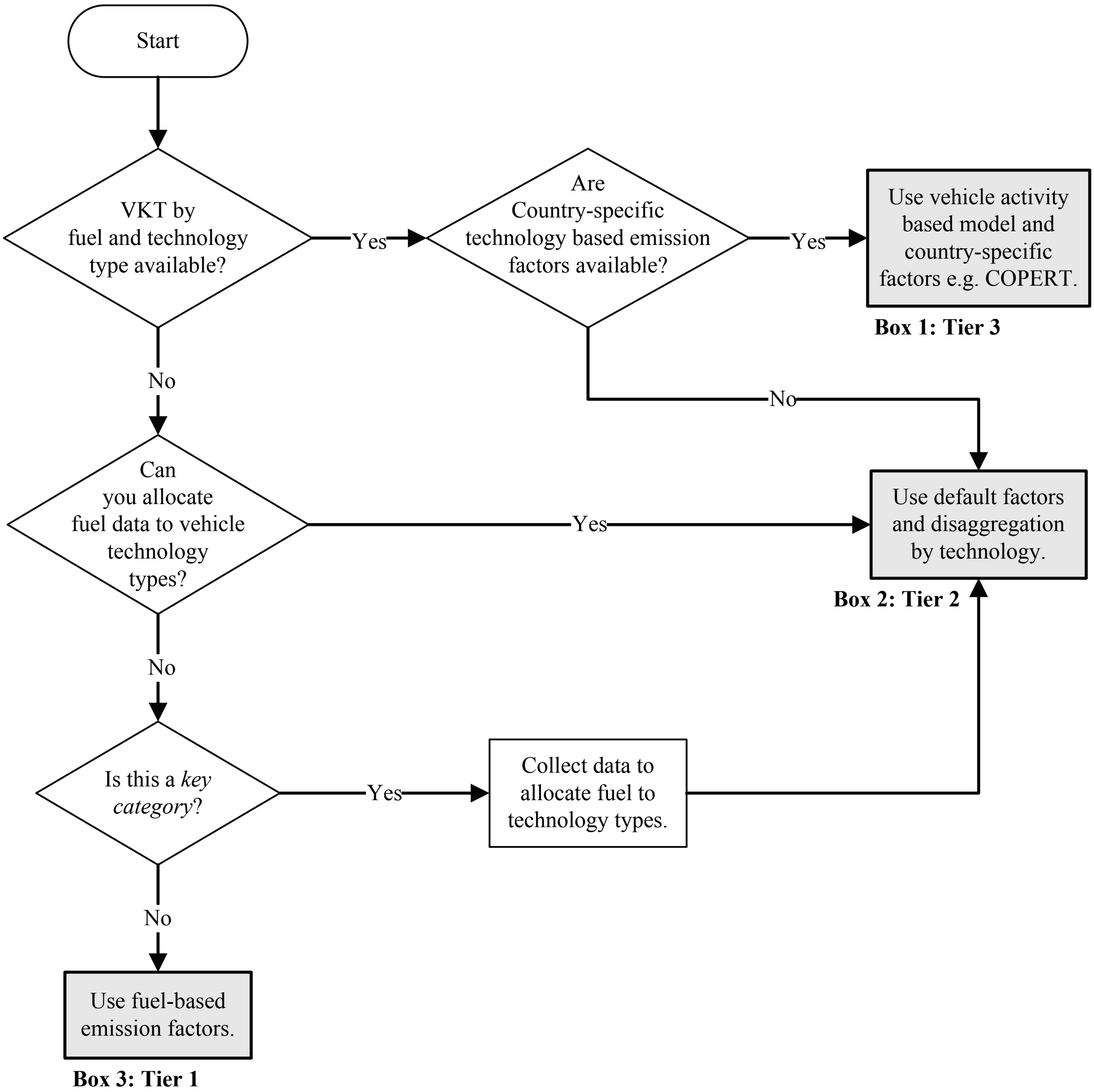
The *2006 IPCC Guidelines* generally provide advice on estimation methods at three levels of detail, from tier 1 (the default method) to tier 3 (the most detailed method). The advice consists of mathematical specification of the methods, information on emission factors or other parameters to use in generating 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 CH_4 and N_2O 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 volumes[13] 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 o Choice of Method, including decision trees and definition of tiers. o Choice of Emission Factor o Choice of Activity Data o Completeness o Developing a Consistent Time Series
• Uncertainty Assessment o Emission Factor Uncertainties o 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 CO_2 capture and storage*: These emissions are covered comprehensively, including fugitive losses from CO_2 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 CO_2 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 CO_2 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_2 and that of CO_2 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 (NF_3), trifluoromethyl sulphur pentafluoride (SF_5CF_3), 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 CO_2 emissions due to land use change in wetlands. However, due to limited availability of scientific information, methods for CH_4 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

- *CO_2 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-CO_2 species eventually oxidises to CO_2 in the atmosphere; and this amount can be estimated from the emissions estimates of the non-CO_2 gases. In some cases the emissions of these non-CO_2 gases contain very small amounts of carbon compared to the CO_2 estimate and it may be more accurate to base the CO_2 estimate on the total carbon. See Volume 1 Section 7.2.1.5 for an approach to estimating these inputs of CO_2 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 (N_2O), but provides estimation methods only for a subset of these, associated with agricultural sources of ammonia (NH_3) 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 N_2O emission attributed to the country responsible for the nitrogen originally emitted.

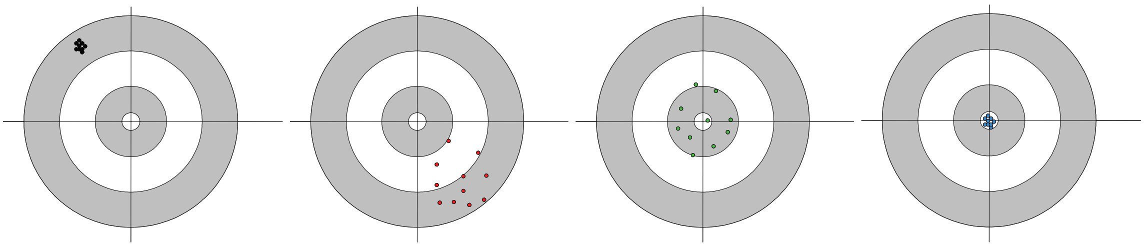
- *Relationship to entity- or project level estimates*: The Guidelines are intended to help prepare national inventories of emissions by sources and removals by sinks. Nonetheless, the Guidelines can also be relevant for estimating actual emissions or removals at the entity or project level.

GLOSSARY

Accuracy

Accuracy is a relative measure of the exactness of an emission or removal estimate. Estimates should be accurate in the sense that they are systematically neither over nor under true emissions or removals, so far as can be judged, and that uncertainties are reduced so far as is practicable. Appropriate methodologies conforming to guidance on *good practices* should be used to promote accuracy in inventories. Accuracy should be distinguished from precision as illustrated below.

Illustration of Accuracy and Precision: (a) inaccurate but precise; (b) inaccurate and imprecise; (c) accurate but imprecise; and (d) precise and accurate.



(a) (b) (c) (d)

Activity

A practice or ensemble of practices that take place on a delineated area over a given period of time.

Activity data

Data on the magnitude of a human activity resulting in emissions or removals taking place during a given period of time. Data on energy use, metal production, land areas, management systems, lime and fertilizer use and waste arisings are examples of activity data.

Anaerobic

Conditions in which oxygen is not readily available. These conditions are important for the production of methane emissions. Whenever organic material decomposes in anaerobic conditions (in landfills, flooded rice fields, etc.) methane is likely to be formed.

Andosol

A soil developed in volcanic ash. Generally andosols have good drainage and are prone to fertility problems.

Arithmetic mean

The sum of the values divided by the number of values.

Auto producer

An enterprise which generates electricity or heat for its own use and/or sells it as a secondary activity i.e., not as its main business.

Back-casting

The opposite of forecasting. Predicting conditions in the past from current conditions.

Backflows

By-product oils from petrochemical processing of refinery products which are generally returned to the refinery for further processing into petroleum products.

Base year

The starting year for the inventory. Currently this is typically 1990.

Bias

A systematic error of the observation method, whose magnitude in most cases is unknown. It can be introduced by using measuring equipment that is improperly calibrated, by selecting items from a wrong population or by favouring certain elements of a population, etc. For example: Estimating the total fugitive emission from gas transport and distribution using only measurements of leakage from high/medium pressure pipelines can lead to bias if the leakage in the lower pressure distribution network (which is significantly more difficult to measure) is neglected.

Biofuels
Any fuels derived from biomass, either deliberately grown or from waste products. Peat is not considered a biofuel in these guidelines due to the length of time required for peat to re-accumulate after harvest.

Biogenic carbon
Carbon derived from biogenic (plant or animal) sources excluding fossil carbon. Note that peat is treated as a fossil carbon in these guidelines as it takes so long to replace harvested peat.

Biological treatment of waste
Composting and anaerobic digestion of organic wastes, such as food waste, garden/park waste and sludge, to reduce volume in the waste material, stabilisation of waste, and destruction of pathogens in the waste material. This includes mechanical-biological treatment.

Biomass
(1) The total mass of living organisms in a given area or of a given species usually expressed as dry weight.

(2) Organic matter consisting of or recently derived from living organisms (espically regarded as fuel) excluding peat. Includes products, by-products and waste derived from such material.

Blowing agent (for foam production)
A gas, volatile liquid, or chemical that generates gas during the foaming process. The gas creates bubbles or cells in the plastic structure of a foam.

Bootstrap technique
Bootstrap technique is a type of computationally intensive statistical methods which typically uses repeated resampling from a set of data to assess variability of parameter estimates.

Boreal
See *polar/boreal*.

Calcium carbide
Calcium carbide is used in the production of acetylene, in the manufacture of cyanamide (a minor historical use), and as a reductant in electric arc steel furnaces. It is made from calcium carbonate (limestone) and carbon-containing reductant (e.g., petroleum coke).

Carbon budget
The balance of the exchanges of carbon between carbon pools or within one specific loop (e.g., atmosphere – biosphere) of the carbon cycle.

Carbon dioxide equivalent
A measure used to compare different greenhouse gases based on their contribution to radiative forcing. The UNFCCC currently (2005) uses global warming potentials (GWPs) as factors to calculate carbon dioxide equivalent (see below).

Category
Categories are subdivisions of the four main sectors Energy; Industrial Processes and Product Use (IPPU); Agriculture, Forestry and Other Land Use (AFOLU); and waste. Categories may be further divided into sub-categories.

Census
Data collected by interrogation or count of an entire population.

Chlorofluorocarbons (CFCs)
Halocarbons containing only chlorine, fluorine, and carbon atoms. CFCs are both ozone-depleting substances (ODSs) and greenhouse gases.

Chronosequence
Chronosequences consist of measurements taken from similar but separate locations that represent a temporal sequence in land use or management, for example, years since deforestation. Efforts are made to control all other between-site differences (e.g., by selecting areas with similar soil type, topography, previous vegetation). Chronosequences are often used as a surrogate for experimental studies or measurements repeated over time at the same location.

Coefficient of variation

Statistical definition: The coefficient of variation, v_x is the ratio of the population standard deviation, σ_x, and mean, μ_x, where $v_x = \sigma_x / \mu_x$. It also frequently refers to the sample coefficient of variation, which is the ratio of the sample standard deviation and sample mean.[1]

Cogeneration

See: Combined Heat and Power (CHP) generation.

Combined heat and power (CHP)

Combined heat and power (CHP), also known as cogeneration, is the simultaneous production of both electricity and useful heat for application by the producer or to be sold to other users with the aim of better utilisation of the energy used. Public utilities may utilise part of the heat produced in power plants and sell it for public heating purposes. Industries as auto-producers may sell part of the excess electricity produced to other industries or to electric utilities.

Comparability

Comparability means that estimates of emissions and removals reported by countries in inventories should be comparable among countries. For this purpose, countries should use agreed methodologies and formats for estimating and reporting inventories.

Completeness

Completeness means that an inventory covers all sources and sinks and gases included in the *IPCC Guidelines* for the full geographic coverage in addition to other existing relevant source/sink categories which are specific to individual countries (and therefore may not be included in the *IPCC Guidelines*).

Confidence

The term 'confidence' is used to represent trust in a measurement or estimate. Having confidence in inventory estimates does not make those estimates more accurate or precise; however, it will eventually help to establish a consensus regarding whether the data can be applied to solve a problem. This usage of confidence differs substantially from the statistical usage in the term confidence interval.

Confidence interval

The value of the quantity for which the interval is to be estimated is a fixed but unknown constant, such as the annual total emissions in a given year for a given country. The confidence interval is a range that encloses the true value of a unknown fixed quantity with a specified confidence (probability). Typically, a 95 percent confidence interval is assumed. From a traditional statistical perspective, the 95 percent confidence interval has a 95 percent probability of enclosing the true but unknown value of the quantity. An alternative interpretation is that the confidence interval is a range that may safely be declared to be consistent with observed data or information. The 95 percent confidence interval is enclosed by the 2.5^{th} and 97.5^{th} percentiles of the PDF.

Consistency

Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base year and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. An inventory using different methodologies for different years can be considered to be consistent if it has been estimated in a transparent manner taking into account the guidance in Volume 1 on good practice in time series consistency.

Correlation

Mutual dependence between two quantities. See *correlation coefficient*.

Correlation coefficient

A number lying between –1 and +1, which measures the mutual dependence between two variables that are observed together. A value of +1 means that the variables have a perfect linear relationship; a value of –1 means that there is a perfect inverse linear relation; and a value of 0 means that there is no straight line relation. It is defined as the covariance of the two variables divided by the product of their standard deviations.

Country-specific data

Data for either activities or emissions that are based on research carried out on sites either in that country or otherwise representative of that country.

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[1] 'Coefficient of variation' is the term, which is frequently replaced by 'error' in a statement like 'the error is 5%'.

Cruise

(When applied to aircraft) All aircraft activities that take place at altitudes above 914 metres (3000 feet) including any additional climb or descent operations above this altitude. There is no upper limit.

Decision tree

A decision tree is a flow chart describing the specific ordered steps which need to be followed to develop an inventory or an inventory component in accordance with the principles of *good practice*.

Distribution function

A distribution function or cumulative distribution function $F(x)$ for a random variable X specifies the probability $P(X \leq x)$ that X is less than or equal to x.

Emission factor

A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions.

Emissions

The release of greenhouse gases and/or their precursors into the atmosphere over a specified area and period of time. (UNFCCC Article 1.4)

Energy recovery

A form of resource recovery in which the organic fraction of waste is converted to some form of usable energy. Recovery may be achieved through the combustion of processed or raw refuse to produce steam through the pyrolysis of refuse to produce oil or gas; and through the anaerobic digestion of organic wastes to produce methane gas.

Enhanced coal bed methane (recovery)

Increased CH4 recovery produced by the injection of CO_2 into coal seams.

Estimation

The process of calculating emissions and/or removals.

Evaporative emissions

Evaporative emissions fall within the class of fugitive emissions and are released from area (rather than point) sources. These are often emissions of Non-Methane Volatile Organic Compounds (NMVOCs), and are produced when the product is exposed to the air – for example in the use of paints or solvents.

Excluded carbon

Carbon in non-energy uses of fossil fuels (feed stocks, reductant and non-energy products) excluded from fuel combustion.

Expert judgement

A carefully considered, well-documented qualitative or quantitative judgement made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field.

Feedstock

Fossil fuels used as raw materials in chemical conversion processes to produce primarily organic chemicals and, to a lesser extent, inorganic chemicals.

First use

Distinguishes first uses (and related emissions) from later non-energy uses of fossil fuels. For example, first-use emissions from lubricants are those which take place as a result of oxidation during use as a lubricant. Used lubricants may be used subsequently for heat raising as waste oils.

Flaring

Deliberate burning of natural gas and waste gas/vapour streams, without energy recovery.

Fluorocarbons

Halocarbons containing fluorine atoms, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Flux

(1) Raw materials, such as limestone, dolomite, lime, and silica sand, which are used to reduce the heat or other energy requirements of thermal processing of minerals (such as the smelting of metals). Fluxes also may serve a dual function as a slagging agent.

(2) The rate of flow of any liquid or gas, across a given area; the amount of this crossing a given area in a given time. E.g., "Flux of CO_2 absorbed by forests".

Fossil carbon

Carbon derived from fossil fuel or other fossil source.

Fuel

Any substance burned as a source of energy such as heat or electricity. See also *Primary Fuels* and *Secondary Fuels*.

Fuel combustion

Within the Guidelines fuel combustion is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.

Fuel wood

Wood used directly as fuel.

Fugitive Emissions

Emissions that are not emitted through an intentional release through stack or vent. This can include leaks from industrial plant and pipelines.

Global warming potential

Global Warming Potentials (GWP) are calculated as the ratio of the radiative forcing of one kilogramme greenhouse gas emitted to the atmosphere to that from one kilogramme CO_2 over a period of time (e.g., 100 years).

Good Practice

Good Practice is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over- nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible.

Good Practice covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties and data archiving and reporting to promote transparency.

Ground truth

A term used for data obtained by measurements on the ground, usually as validation for remote sensing, e.g., satellite data.

Hydrocarbon

Strictly defined as molecules containing only hydrogen and carbon. The term is often used more broadly to include any molecules in petroleum which also contains molecules with S, N, or O An unsaturated hydrocarbon is any hydrocarbon containing olefinic or aromatic structures.

Hydrochlorofluorocarbons (HCFCs)

Halocarbons containing only hydrogen, chlorine, fluorine and carbon atoms. Because HCFCs contain chlorine, they contribute to ozone depletion. They are also greenhouse gases.

Hydrofluorocarbons (HFCs)

Halocarbons containing only hydrogen, fluorine and carbon atoms. Because HFCs contain no chlorine, bromine, or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases.

Hydrofluoroethers (HFEs)

Chemicals composed of hydrogen, fluorine and carbon atoms, with ether structure. Because HFES contain no chlorine, bromine, or iodine, they do not deplete the ozone layer. Like other halocarbons, they are potent greenhouse gases.

Independence

Two random variables are independent if there is a complete absence of association between how their sample values vary. The most commonly used measure of the lack of independence between two random variables is the correlation coefficient.

Key category

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

Key source

See *key category*.

Kilns

A tubular heating apparatus used in the manufacture of cement, lime and other materials. The calcination reaction may take place in the kiln itself, or, where so-equipped, it may partly or completely take place in a preheater and/or precalciner apparatus ahead of the kiln.

Land cover

The type of vegetation , rock, water etc. covering the earth’s surface.

Land use

The type of activity being carried out on a unit of land.

Note: in Volume 4 (AFOLU), broad land-use categories are defined in Chapter 2. It is recognized that these categories are a mixture of land cover (e.g., Forest, Grassland, Wetlands) and land use (e.g., Cropland, Settlements) classes.

Landfill gas

Municipal solid waste contains significant portions of organic materials that produce a variety of gaseous products when deposited, compacted, and covered in landfills. Anaerobic bacteria thrive in the oxygen-free environment, resulting in the decomposition of the organic materials and the production of primarily carbon dioxide and methane. Carbon dioxide is likely to leach out of the landfill because it is soluble in water. Methane, on the other hand, which is less soluble in water and lighter than air, is likely to migrate directly to the atmosphere.

LTO (landing and take-off) cycle

All aircraft activities that occur under 914 metres (3 000 feet) including idling aircraft engines, taxi-out, take-off, climb up to 914 metres, descend, approach and taxi-in. Note: some gatherers of statistics count either single take-off or landing as one cycle; however, it is both one take-off and one landing that together define the LTO cycle.

Lubricants

Lubricants are hydrocarbons produced from distillate or residue, and they are mainly used to reduce friction between bearing surfaces. This category includes all finished grades of lubricating oil, from spindle oil to cylinder oil, and those used in greases, including motor oils and all grades of lubricating oil base stocks.

Manure

Waste materials produced by domestic livestock which can be managed for agricultural purposes. When manure is managed in a way that involves anaerobic decomposition, significant emissions of methane can result.

Mean

The mean is a value around which values sampled from a probability distribution tend to lie. The sample mean or arithmetic average is an estimator for the mean. It is an unbiased and consistent estimator of the population mean (expected value) and is itself a random variable with its own variance value. The sample mean is the sum of values divided by the number of values:

$\bar{x} = \frac{1}{n}\sum_{i}^{n} x_i$ (*xi*, where *i* = 1,…., *n* are items of a sample).

Median

The median or population median is a value which divides the integral of a probability density function (PDF) into two halves. For symmetric PDFs, it equals the mean. The median is the 50th population percentile.

The sample median is an estimator of the population median. It is the value that divides an ordered sample into two equal halves. If there are $2n + 1$ observations, the median is taken as the $(n + 1)^{th}$ member of the ordered sample. If there are $2n$, it is taken as being halfway between the n^{th} and $(n + 1)^{th}$.

Mode

The mode of a distribution is the value which has the highest probability of occurrence. Distributions can have one or more modes. In practice, we usually encounter distributions with only one mode. In this case, the mode or population mode of a PDF is the measure of a value around which values sampled from a probability distribution tend to lie.

The sample mode is an estimator for the population mode calculated by subdividing the sample range into equal subclasses, counting how many observations fall into each class and selecting the centre point of the class (or classes) with the greatest number of observations.

Model

A model is a quantitatively-based abstraction of a real-world situation which may simplify or neglect certain features to better focus on its more important elements.

Example: the relationship that emissions equal an emission factor times an activity level is a simple model. The term ‘model’ is also often used in the sense of a computer software realisation of a model abstraction.

Monte Carlo method

In these guidelines a Monte Carlo method is recommended to analyse the uncertainty of the inventory. The principle of Monte Carlo analysis is to perform the inventory calculation many times by computer, each time with the uncertain emission factors or model parameters and activity data chosen randomly (by the computer) within the distribution on uncertainties specified initially by the user. Uncertainties in emission factors and/or activity data are often large and may not have normal distributions. In this case the conventional statistical rules for combining uncertainties become very approximate. Monte Carlo analysis can deal with this situation by generating an uncertainty distribution for the inventory estimate that is consistent with the input uncertainty distributions on the emission factors, model parameters and activity data.

Non-energy products

Primary or secondary fossil fuels which are used directly for their physical or diluent properties. Examples are: lubricants, paraffin waxes, bitumen, and white spirits and mineral turpentine (as solvent).

Non-energy use

Within the *Guidelines* this term refers to the use of fossil fuels as *Feedstock*, *Reductant* or *Non-energy products.* However, the use of this term differs between countries and sources of energy statistics. In most energy statistics, e.g., of the International Energy Agency (IEA), fuel inputs of *reductants* to blast furnaces are not included but accounted for as inputs to a fuel conversion activity transforming coke and other inputs to blast furnace gas.

Non-marketed lime production

Lime production occurring at facilities where the primary purpose is the production of lime as an intermediate input: such as plants that produce steel, synthetic soda ash, calcium carbide, magnesia and magnesium metal, as well as copper smelter and sugar mills. The lime produced by these facilities is often used on site and thus is often not reported in national statistics. Also referred to as in-house lime production.

Non-Methane Volatile Organic Compounds (NMVOCs)

A class of emissions which includes a wide range of specific organic chemical substances. Non-Methane Volatile Organic Compounds (NMVOCs) play a major role in the formation of ozone in the troposphere (lower atmosphere). Ozone in the troposphere is a greenhouse gas. It is also a major local and regional air pollutant, causing significant health and environmental damage. Because they contribute to ozone formation, NMVOCs are considered "precursor" greenhouse gases. NMVOCs, once oxidized in the atmosphere, produce carbon dioxide.

Normal distribution

The normal (or Gaussian) distribution has the PDF given in the following equation and is defined by two parameters (the mean μ and the standard σ deviation).

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}, \text{ for } -\infty \leq x \leq \infty.$$

Observational data
Observational data is empirical data from instrumental (usually monitoring equipment) or manual methods (through counts in a survey or census).

Off-gas
The exhaust gas from a chemical process (combustion or non-combustion). The off gas may be vented to the atmosphere, burned for energy recovery or flared (without energy recovery), or used as a feedstock for another chemical process. Secondary products may also be recovered from the off gas.

Open burning of waste
The combustion of unwanted combustible materials such as paper, wood, plastics, textiles, rubber, and other debris in the open or at an open dump site, where smoke and other emissions are released directly into the air without passing through a chimney or stack. Open burning can also include incineration devices that do not control the combustion air to maintain an adequate temperature and do not provide sufficient residence time for complete combustion.

Oxidation
Chemically transform of a substance by combining it with oxygen.

Ozone-depleting substances (ODS)
A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone.

PDF
See *Probability density function*.

Percentile
The k^{th} percentile or population percentile is a value which separates the lowest k^{th} part of the integral of the probability density function (PDF) – i.e., an integral of a PDF tail from the k^{th} percentile towards lower probability densities.

The k^{th} population percentile ($0 \leq k \leq 100$) of a population with a distribution function $F(x)$ equals to z where z satisfies $F(z) = k/100$

Sample k^{th} percentile is an approximation for the population percentile which is derived from a sample. It is the value below which k percent of the observations lie.

Perfluorocarbons (PFCs)
Synthetically produced halocarbons containing only carbon and fluorine atoms. They are characterized by extreme stability, non-flammability, low toxicity, zero ozone depleting potential, and high global warming potential.

Polar/boreal
Regions where mean annual temperature (MAT) is less than 0 ^{o}C.

Pool/carbon pool
A reservoir. A component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored. Examples of carbon pools are forest biomass, wood products, soils and the atmosphere. The units are mass.

Population
The population is the totality of items under consideration. In the case of a random variable, the probability distribution is considered to define the population of that variable.

Primary fuels
Fuels which are extracted directly from natural resources. Examples are: crude oil, natural gas, coals, etc.

Precision
Precision is the inverse of uncertainty in the sense that the more precise something is, the less uncertain it is.

Closeness of agreement between independent results of measurements obtained under stipulated conditions (see also *accuracy*).

Probability
A probability is a real number in the scale 0 to 1 attached to a random event. There are different ways in which probability can be interpreted. One interpretation considers a probability as having the nature of a relative frequency (i.e., the proportion of all outcomes corresponding to an event), whilst another interpretation regards a probability as being a measure of degree of belief.

Probability density function
The Probability Density Function (PDF) describes the range and relative likelihood of possible values. The PDF can be used to describe *uncertainty* in the estimate of a quantity that is a fixed constant whose value is not exactly known, or it can be used to describe inherent *variability*. The purpose of the uncertainty analysis for the emission inventory is to quantify *uncertainty* in the unknown fixed value of total emissions as well as emissions and activity pertaining to specific categories. Thus, throughout these guidelines it is presumed that the PDF is used to estimate uncertainty, and not variability, unless otherwise stated.

Probability distribution
Statistical definition: A function giving the probability that a random variable takes any given value or belongs to a given set of values. The probability on the whole set of values of the random variable equals 1.

Process emissions
Emissions from industrial processes involving chemical transformations other than combustion.

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

Quality Control
Quality Control (QC) is a system of routine technical activities, to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

(i) Provide routine and consistent checks to ensure data integrity, correctness, and completeness;

(ii) Identify and address errors and omissions;

(iii) Document and archive inventory material and record all QC activities.

QC activities include general methods such as accuracy checks on data acquisition and calculations and the use of approved standardised procedures for emission calculations, measurements, estimating uncertainties, archiving information and reporting. More detailed QC activities include technical reviews of source categories, activity and emission factor data, and methods.

Removals
Removal of greenhouse gases and/or their precursors from the atmosphere by a sink.

Reporting
The process of providing results of the inventory as described in volume 1 chapter 8.

Reservoir
(1) A component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored. (UNFCCC Article 1.7)

(2) Water bodies regulated for human activities (energy production, irrigation, navigation, recreation etc.) where substantial changes in water area due to water level regulation may occur.

Secondary fuels
Fuels manufactured from primary fuels. Examples are: cokes, motor gasoline and coke oven gas, blast furnace gas.

Sequestration
The process of storing carbon in a carbon pool.

Sink
Any process, activity or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas from the atmosphere. (UNFCCC Article 1.8) Notation in the final stages of reporting is the negative (-) sign.

Source
Any process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas into the atmosphere. (UNFCCC Article 1.9) Notation in the final stages of reporting is the positive (+) sign.

Standard deviation
The population standard deviation is the positive square root of the variance. It is estimated by the sample standard deviation that is the positive square root of the sample variance.

Surrogate data
Surrogate data is data that is used in place of the actual data, where the specific data needed is unobtainable. Often surrogate data is needed to describe changes in an emission source over time, for example population change may be used to approximate change in waste arisings.

Survey data
Survey data is derived from random sampling of a population and does not include real data for the whole population, e.g., the number of animals in a country or region by surveying a discrete selection of farms and groups of farms in a country or region, or using more general surrogate data and assumptions.

Systematic and random errors
Systematic error (i.e., bias) is the difference between the true, but usually unknown, value of a quantity being estimated, and the mean observed value as would be estimated by the sample mean of an infinite set of observations. The random error of an individual measurement is the difference between an individual measurement and the above limiting value of the sample mean.

Systematic error
See *systematic and random errors*.

Temperate, cold
Areas where mean annual temperature (MAT) is between 0 – 10 ^{o}C.

Temperate, warm
Areas where mean annual temperature (MAT) is between 10 – 20 ^{o}C.

Time series
A time series is series of values which are affected by random processes and which are observed at successive (usually equidistant) points in time.

Transparency
Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of inventories is fundamental to the success of the process for the communication and consideration of information.

Trend
The trend of a quantity measures its change over a time period, with a positive trend value indicating growth in the quantity, and a negative value indicating a decrease. It is defined as the ratio of the change in the quantity over the time period, divided by the initial value of the quantity, and is usually expressed either as a percentage or a fraction.

Tropical
Areas where mean annual temperature (MAT) is more than 20 ^{o}C.

Unbiased estimator
An unbiased estimator is a statistic whose expected value equals the value of the parameter being estimated. Note that this term has a specific statistical meaning and that an estimate of a quantity calculated from an unbiased estimator may lack bias in the statistical sense, but may be biased in the more general sense of the word if the sample has been affected by unknown systematic error. Thus, in statistical usage, a biased estimator can be understood as a deficiency in the statistical evaluation of the collected data, and not in the data themselves or in the method of their measurement or collection. For example, the arithmetic mean (average) $\overline{x}$ is an unbiased estimator of the expected value (mean).

Uncertainty
Lack of knowledge of the true value of a variable that can be described as a probability density function characterizing the range and likelihood of possible values. Uncertainty depends on the analyst's state of knowledge, which in turn depends on the quality and quantity of applicable data as well as knowledge of underlying processes and inference methods. (See Volume 1 Chapter 3.)

Uncertainty analysis
An uncertainty analysis of a model aims to provide quantitative measures of the uncertainty of output values caused by uncertainties in the model itself and in its input values, and to examine the relative importance of these factors.

Validation
Validation is the establishment of sound approach and foundation. In the context of emission inventories, validation involves checking to ensure that the inventory has been compiled correctly in line with reporting instructions and guidelines. It checks the internal consistency of the inventory. The legal use of validation is to give an official confirmation or approval of an act or product.

Variability
This refers to observed differences attributable to true heterogeneity or diversity in a population. Variability derives from processes which are either inherently random or whose nature and effects are influential but unknown. Variability is not usually reducible by further measurement or study, but can be characterised by quantities such as the sample variance.

Verification
Verification refers to the collection of activities and procedures that can be followed during the planning and development, or after completion of an inventory that can help to establish its reliability for the intended applications of that inventory.

Typically, methods external to the inventory are used to check the truth of the inventory, including comparisons with estimates made by other bodies or with emission and uptake measurements determined from atmospheric concentrations or concentration gradients of these gases.

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