INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE
NATIONAL GREENHOUSE GAS INVENTORIES PROGRAMME

2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

IPCC National Greenhouse Gas Inventories Programme

IGES

Supporting material prepared for consideration by the Intergovernmental Panel on Climate Change (IPCC). This supporting material has not been subject to formal IPCC review processes.

This report was finalised at the IPCC meeting on the Promotion of the IPCC Guidelines held in Geneva, October 2007. The IPCC would like to thank all the participants for their contributions.

Published by the Institute for Global Environmental Strategies (IGES), Hayama, Japan on behalf of the IPCC

Please cite as:

IPCC 2008, 2006 IPCC Guidelines for National Greenhouse Gas Inventories – A primer, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Miwa K., Srivastava N. and Tanabe K. (eds). Published: IGES, Japan.

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Printed in Japan

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INTRODUCTION

This paper introduces the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*2006 Guidelines*; IPCC 2006), summarises the basic approach for inventory development, and provides guidance on their use. It is hoped this will give a better understanding of greenhouse gas inventories to a wider audience.

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

The *2006 Guidelines* provide methodologies for making estimates of national anthropogenic emissions and removals of greenhouse gases. These methodologies can be used to assist Parties to the UN Framework Convention on Climate Change (UNFCCC) in fulfilling their commitments to develop inventories of anthropogenic emissions and removals of greenhouse gases not controlled by the Montreal Protocol.

Emission inventories are not just needed for reporting emissions and removals; they are also essential tools in developing policies and in monitoring the impact of those policies. As such they provide invaluable information for those developing policies related to climate change and air pollution.

IPCC Guidelines and the UNFCCC

Parties to the UNFCCC have agreed (amongst other things) to "*Develop, periodically update, publish and make available … national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties;*" (UNFCCC 1992). The "*comparable methodologies*" agreed on are those produced by the Intergovernmental Panel on Climate Change (IPCC).

The *Revised 1996 Guidelines for National Greenhouse Gas Inventories* (*Revised 1996 Guidelines*, IPCC 1997), together with the two volumes on inventory good practice guidance - the *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (*GPG 2000*, IPCC 2000) and the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (*GPG-LULUCF*, IPCC 2003)-, are to be used by Parties included in Annex I of the UNFCCC (Annex I Parties, developed countries) while the *Good Practice Guidance* reports are encouraged for use by Parties not included in Annex I of the UNFCCC (Non-Annex I Parties).

The *2006 Guidelines* were produced at the invitation of the UNFCCC in 2002 to update the *Revised 1996 Guidelines* and associated good practice guidance in 2006. The IPCC's Task Force on Inventories undertook this task and the IPCC Panel XXV (Port Louis, Mauritius, April 2006) adopted and accepted the *2006 Guidelines*. The UNFCCC is currently considering the use of the *2006 Guidelines*. The *2006 Guidelines* are a repository of the best available, peer-reviewed parameters and methods for national greenhouse gas inventories. These methods and parameters can also be used within the structure of the previous guidelines.

The *2006 Guidelines* are the work of over 250 authors nominated by governments and international organisations and selected in accordance with the IPCC procedures. The final list of authors was selected to ensure as wide a geographic representation as possible as well as to ensure sufficient coverage of all potential sources. Sectoral meetings were held enabling authors to discuss and agree common approaches, followed by drafting and email exchanges to produce the completed guidelines. Following drafting, the complete document was peer reviewed twice, first by experts alone and the second time by experts and governments. After each review an expert meeting considered the comments and, if necessary, edited the text. In all over 6,000 comments were received. Following a period of government consideration the final draft was adopted and accepted by the IPCC in April 2006.

Improvements

These *2006 Guidelines* are the most up-to-date guidance available to inventory compilers. They are the latest in a series of publications started in 1995 and built on the earlier guidance. The *2006 Guidelines* provide users with a number of key advantages compared to earlier guidance:

- Improved accuracy: The guidelines now include updated methods and improved default values based on up-to-date information thus improving the overall accuracy of estimates. Guidance for all sources and sinks now gives actual annual estimates, as opposed to the earlier "potential" methods.
- More complete: Guidance is given on more sources and sinks as they have been identified since 1996. Guidance on land use sectors has been made more complete and consistent across all land uses. More fluorinated greenhouse gases are included as information on their

use and release has become available.

- Reduced scope for errors: The source categories have been restructured to reduce the possibilities for double counting or omissions. The most appropriate choice of method has been made easier by incorporating and updating the earlier good practice guidance into the individual sector methods.
- Clearer guidance: Integrating all the good practice guidance into the methodology report ensures that users can more easily find all the relevant information they need. The guidance starts with one general volume on overall QA/QC and good practice issues and sector-specific matters are all dealt with in the sector volumes.
- Resource-relevant methods: Differing methodologies and their selection enable inventory developers with limited resources to complete their national estimates while also allowing those with greater resources to use more detailed and accurate methods.

USING THE *2006 GUIDELINES*

This section explains the approach in the *2006 Guidelines* to estimating emissions and removals of greenhouse gases. It starts by providing some key definitions, then outlines the inventory process and describes how inventories should be managed. The final part is a step-by-step description of compiling an inventory.

Elements of Greenhouse Gas Inventories

Greenhouse gas inventories are estimates of all the anthropogenic emissions and removals of specified gases from all categories and sectors from a given area during a specified time frame. These parameters need to be clearly defined in order for inventories to be consistent and comparable.

Anthropogenic

Anthropogenic emissions and removals means that greenhouse gas emissions and removals included in national inventories are a result of human activities. The distinction between natural and anthropogenic emissions and removals follows straightforwardly from the data used to quantify human activity. In the Agriculture, Forestry and Other Land Use (AFOLU) Sector, emissions and removals on managed land are taken as a proxy for anthropogenic emissions and removals. Inter-annual variations in natural background emissions and removals, though these can be significant, are assumed to average out over time.

Greenhouse gases

The gases that contribute to climate change have been identified in IPCC assessment reports. While previous IPCC guidance focused on the gases with Global Warming Potentials (GWPs) identified in the Second Assessment Report (IPCC 1995a; IPCC 1995b), the *2006 Guidelines* cover a longer list of greenhouse gases with GWP values identified in the Third Assessment Report (IPCC 2001a; IPCC 2001b) or potential replacements for them (see Table 1). IPCC guidance is not given for gases covered by Montreal Protocol.

The *2006 Guidelines* also provide information for the reporting of the following precursors: nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO) and sulphur dioxide (SO_2) although methods for estimating emissions of these gases are not given by the *2006 Guidelines* as they are available elsewhere (TFEIP 2006; USEPA - OTAQ 2007).

Table 1 - Greenhouse gases covered in the 2006 Guidelines

Name	Symbol(s)	In IPCC 1996 Guidelines	GWP available in TAR
Carbon Dioxide	CO_2	Yes	Yes
Methane	CH_4	Yes	Yes
Nitrous Oxide	N_2O	Yes	Yes
Hydrofluorocarbons	HFCs (e.g., HFC-23 (CHF_3), HFC-134a (CH_2FCF_3), HFC-152a (CH_3CHF_2))	Yes	Yes
Perfluorocarbons	PFCs (CF_4, C_2F_6, C_3F_8, C_4F_{10}, c-C_4F_8, C_5F_{12}, C_6F_{14})	Yes	Yes
Sulphur Hexafluoride	SF_6	Yes	Yes
Nitrogen Trifluoride	NF_3		Yes
Trifluoromethyl Sulphur Pentafluoride	SF_5CF_3		Yes
Halogenated Ethers	e.g., $C_4F_9OC_2H_5$, $CHF_2OCF_2OC_2F_4OCHF_2$, $CHF_2OCF_2OCHF_2$		Yes
Other halocarbons	e.g., CF_3I, CH_2Br_2, $CHCl_3$, CH_3Cl, CH_2Cl_2		Yes
	$C_3F_7C(O)C_2F_5$, C_7F_{16}, C_4F_6, C_5F_8, c-C_4F_8O		

Geographic area

National inventories include in general greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction. There are some special issues:

- Emissions from fuel use on ships or aircraft engaged in international transport should not be included in national totals but be reported separately.
- CO_2 emissions from road vehicles should be attributed to the country where the fuel was sold. The same principle can be applied to other gases depending on the data used.
- Emissions from coastal and deep sea fishing should be allocated to the country delivering the fuel.
- Military fuel use is reported under "1A5 Non-specified", this includes fuel deliveries for all mobile and stationary consumption of the country unless data exist to separate national and international fuel use.
- Emissions from multilateral operations pursuant to the Charter of the United Nations are not included in national totals.
- Fugitive emissions from pipelines should be allocated according to the national territory of the pipeline, including offshore areas. This implies that emissions from one pipeline may be distributed between two or more countries.
- Any emissions from the injection and possible subsequent leakage of CO_2 stored in geological formations should be included by the country in whose national jurisdiction or by whose international right the point of injection is located. These emissions may cross national boundaries.
- Different approaches to include the impact of harvested wood products (HWP) are under discussion by the UNFCCC and inventory compilers can select any of the approaches under discussion. (Vol.4 Ch.12)

These guidelines may also be applicable at the project scale.

Time: Inventory year and time series

National inventories contain estimates for the calendar year during which the emissions to (or removals from) the atmosphere occur. Where suitable data to follow this principle are missing, emissions/removals may be estimated using data from other years applying appropriate methods such as averaging, interpolation and extrapolation. A sequence of annual greenhouse gas inventory estimates (e.g., each year from 1990 to 2000) is called a time series. Because of the importance of tracking emissions trends over time, countries should ensure that a time series of estimates is as consistent as possible.

Sectors and categories

Greenhouse gas emission and removal estimates are divided into main sectors, which are groupings of related processes, sources and sinks:

- Energy
- Industrial Processes and Product Use (IPPU)
- Agriculture, Forestry and Other Land Use (AFOLU)
- Waste

Each sector comprises individual categories (e.g., transport) and sub-categories (e.g., cars). Countries construct a national total inventory from the sub-category level because accurate estimates can only be made at this level and because this detail makes inventories more useful to policymakers. A national total is calculated by summing up emissions and removals for each gas.

There are two exceptions. Firstly, CO_2 emissions from the use of biomass for fuels are not included in the national totals but are estimated and reported separately. Any net emissions should be covered in the AFOLU Sector.

Secondly, where CO_2 emissions are captured from industrial processes or large combustion sources, emissions should be allocated to the sector generating the CO_2 unless it can be shown that the CO_2 is stored in properly monitored geological storage sites (Vol.2 Ch.5).

Inventory Process and Management

As with the *1996 Guidelines* and the two volumes of the *IPCC Good Practice Guidance* the most common simple methodological approach is to combine information on the extent to which a human activity takes place (called *activity data*) with coefficients which quantify the emissions or removals per unit activity. These are called *emission factors*. The basic equation is therefore:

$$Emissions = Activity\ Data \bullet Emission\ Factor$$

For example, in the Energy Sector fuel consumption would constitute activity data, and mass of carbon dioxide emitted per unit of fuel consumed would be an emission factor. The basic equation can in some circumstances be modified to include other estimation parameters than emission factors. Where time lags are involved, due for example to the time it takes for material to decompose in a landfill or leakage of refrigerants from cooling devices, other methods are provided, for example first order decay methods. The *2006 Guidelines* also allow for more complex modelling approaches, particularly at higher tiers (see later).

Though this simple equation is widely used, the *2006 Guidelines* also contain mass balance methods, for example

the stock change methods used in the AFOLU Sector which estimates CO_2 emissions from changes over time in carbon content of living biomass and dead organic matter pools.

Carbon dioxide from the combustion or decay of short-lived biogenic material removed from where it was grown is reported as zero in the Energy, IPPU and Waste Sectors (for example CO_2 emissions from biofuels [1, 2], and CO_2 emissions from biogenic material in Solid Waste Disposal Sites (SWDS)). In the AFOLU Sector, when using Tier 1 methods for short lived products, it is assumed that the emission is balanced by carbon uptake prior to harvest, within the uncertainties of the estimates, so the net emission is zero. Where higher tier estimation shows that this emission is not balanced by a carbon removal from the atmosphere, this net emission or removal should be included in the emission and removal estimates for AFOLU Sector through carbon stock change estimates. Material with long lifetime is dealt with in the Harvested Wood Products chapter (see Vol.4 Ch.12).

Structure of the Guidelines

Volumes: The *2006 Guidelines* contain 5 volumes, one for each sector (Vols.2-5) and one for general guidance applicable to all sectors (Vol.1) shown in Table2.

Table 2 - 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

[1] CO_2 emissions from the use of biofuels should be reported as an information item for QA/QC purposes.

[2] In these Guidelines peat is assumed *not* to be a biofuel.

This five-volume structure means the cross referencing will be required between two volumes at most: Volume 1 (General Guidance and Reporting), and the relevant sectoral volume.

Chapters: Volume 1 contains chapters that provide detailed cross-cutting guidance by topic as described in more detail below. Volumes 2-5 contain chapters that provide methodological guidance for specific emission and removal categories, along with specific recommendations for uncertainty, QA/QC, time series consistency, and reporting. The volume and chapter structure is presented in Table 2.

Annexes: Annexes are intended to include additional often detailed information beyond what is necessary for a Tier 1 estimate, for example extended data tables.

Appendices: The *2006 Guidelines* present some technical material in appendices, where emissions or removals are poorly understood and where there is insufficient information available to develop reliable, globally applicable, default methods for a particular source or sink. Countries may use appendices as a basis for further methodological development, but a national inventory can be considered complete without the inclusion of estimates for these sources and sinks.

Worksheets: Worksheets are tools designed to provide easy calculation of Tier 1 methodologies. Worksheets are not provided for higher tiers, although they can also be used where the higher tier method is similar to Tier 1 (e.g., where national data is used instead of default data). Some more complex approaches are provided in spreadsheets in the CDROM attached to the *Guidelines* for a few sectors.

Reporting tables: The reporting tables are intended to give sufficient detail required for transparent reporting of national greenhouse gas inventories and follow a disaggregated category list. They include summary tables, sectoral tables, background tables and trend tables. The background tables include summary activity data for increased transparency and to facilitate comparison of data across countries. Reporting tables also include results of a *key category* analysis and uncertainty assessment, memo items (emissions to be reported but not included in national totals) and information items for increased transparency.

Good Practice: How to ensure a quality inventory

In order to promote the development of high quality national greenhouse gas inventories a collection of methodological principles, tasks and procedures were defined in the previous guidelines and collectively referred to as *good practice*. The *2006 Guidelines* refined *good practice* ensuring it is applied uniformly across the entire inventory with sectoral guidance, improving the general guidance and adding additional guidance on data collection. The definition of *good practice* has achieved general acceptance amongst countries as the basis for inventory development. Inventories that are 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*.

In order to produce high quality inventories, despite the varying experience and resources of inventory compilers, the *2006 Guidelines* uses the following concepts:

Tiers: A *tier* represents a level of methodological complexity. Usually three tiers are provided. Tier 1 is the basic method and default factors are supplied; Tier 2 requires country-specific information and Tier 3 is most demanding in terms of complexity and data requirements usually involving detailed modelling. Tiers 2 and 3 are sometimes referred to as *higher tier* methods and are generally considered to be more accurate and appropriate for significant contributors to the national total (see *key categories*, below).

Default data: Tier 1 methods for all categories are designed to use readily available national or international statistics in combination with the default emission factors and additional parameters that are provided, and therefore should be feasible for all countries.

Key categories: The concept of *key category* (Vol.1 Ch.4) is used to identify the categories that have 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 and removals. *Key categories* should be the priority for countries during inventory resource allocation for data collection, compilation and quality assurance/quality control.

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

Inventory quality

These *Guidelines* provide guidance on ensuring quality on all steps of the inventory compilation – from data collection to reporting. They also provide tools to focus resources on the areas where they will most benefit the overall inventory

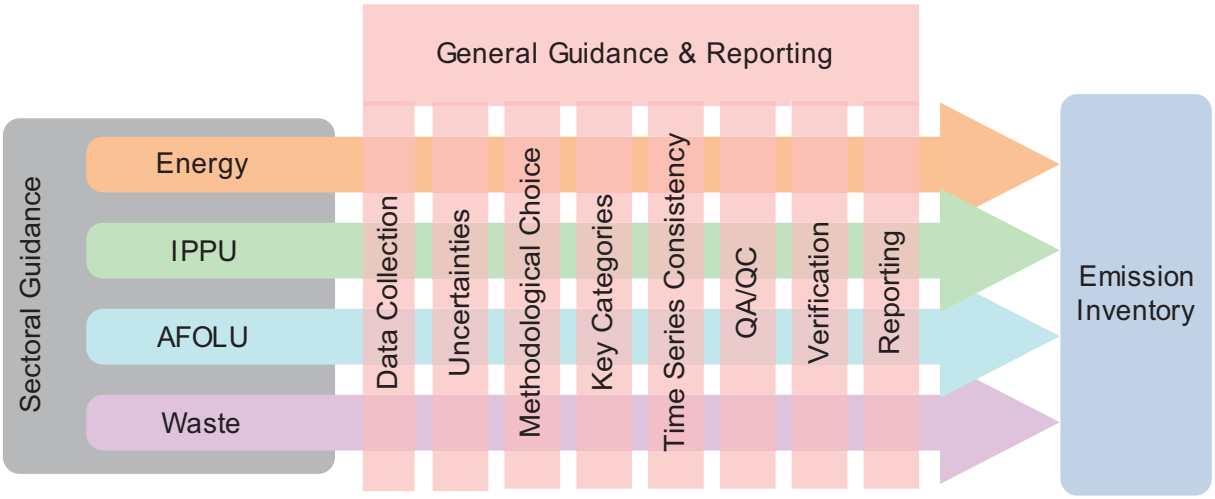

Figure 1 - Relationship between general and sectoral guidance

and encourage continuous improvement. Experience has demonstrated that using a *good practice* approach is a pragmatic means of building inventories that are consistent, comparable, complete, accurate and transparent – and developing them in a manner that improves inventory quality over time. Indicators of inventory quality are:

Transparency: There is sufficient and clear documentation such that all involved can understand how the inventory was compiled and can assure themselves that it meets the *good practice* requirements for national greenhouse gas emissions inventories. Documentation and reporting guidance is provided in Volume 1, Chapters 6 and 8, and in the respective chapters of Volumes 2-5.

Completeness: National, calendar year estimates are reported for all sources and sinks, and gases indicated in Table 1. Where elements are missing their absence should be clearly documented together with a justification for exclusion (see Vols. 2-5).

Consistency: Estimates for different inventory years, gases and categories are made in such a way that differences between years and categories reflect real differences in emissions. Inventory annual trends, as far as possible, should be calculated using the same method and data sources in all years. They should aim to reflect the real annual fluctuations in emissions or removals and not be subject to changes resulting from methodological differences. (Vol.1 Chs.2, 4 & 5)

Comparability: The national greenhouse gas inventory is reported in a way that allows it to be compared with national greenhouse gas inventories for other countries. This comparability should be reflected in appropriate identification of key categories (Vol.1 Ch.4); in the use of the reporting guidance and tables; and use of the classification and definition of categories of emissions and removals presented in Table 8.2 of Volume 1, Chapter 8, and Volumes 2-5.

Accuracy: National greenhouse gas inventories should contain neither over- nor under-estimates so far as can be judged. This means making all endeavours to remove bias from the inventory estimates (Vol.1 Chs.2 & 3 and Vols. 2-5).

Compiling an inventory

Compiling a greenhouse gas inventory is a step-by-step process. Compilation includes the collection of data, estimation of emissions and removals, checking and verification, uncertainty assessment and reporting.

Before undertaking estimates of emissions and removals from specific categories an inventory compiler should become familiar with the material in Volume 1. This Volume provides *good practice guidance* on issues that are common to all the estimation methods covered by the sector-specific guidance provided in Volumes 2 to 5 and reporting instructions (see Figure 1).

The main topics are:

Data collection: The collection of data is a fundamental part of inventory preparation (and sometimes the most difficult and the largest source of inaccuracy). Guidance covers initiating and maintaining a data collection programme; evaluating existing sources of data; and planning new emission measurements and surveys.

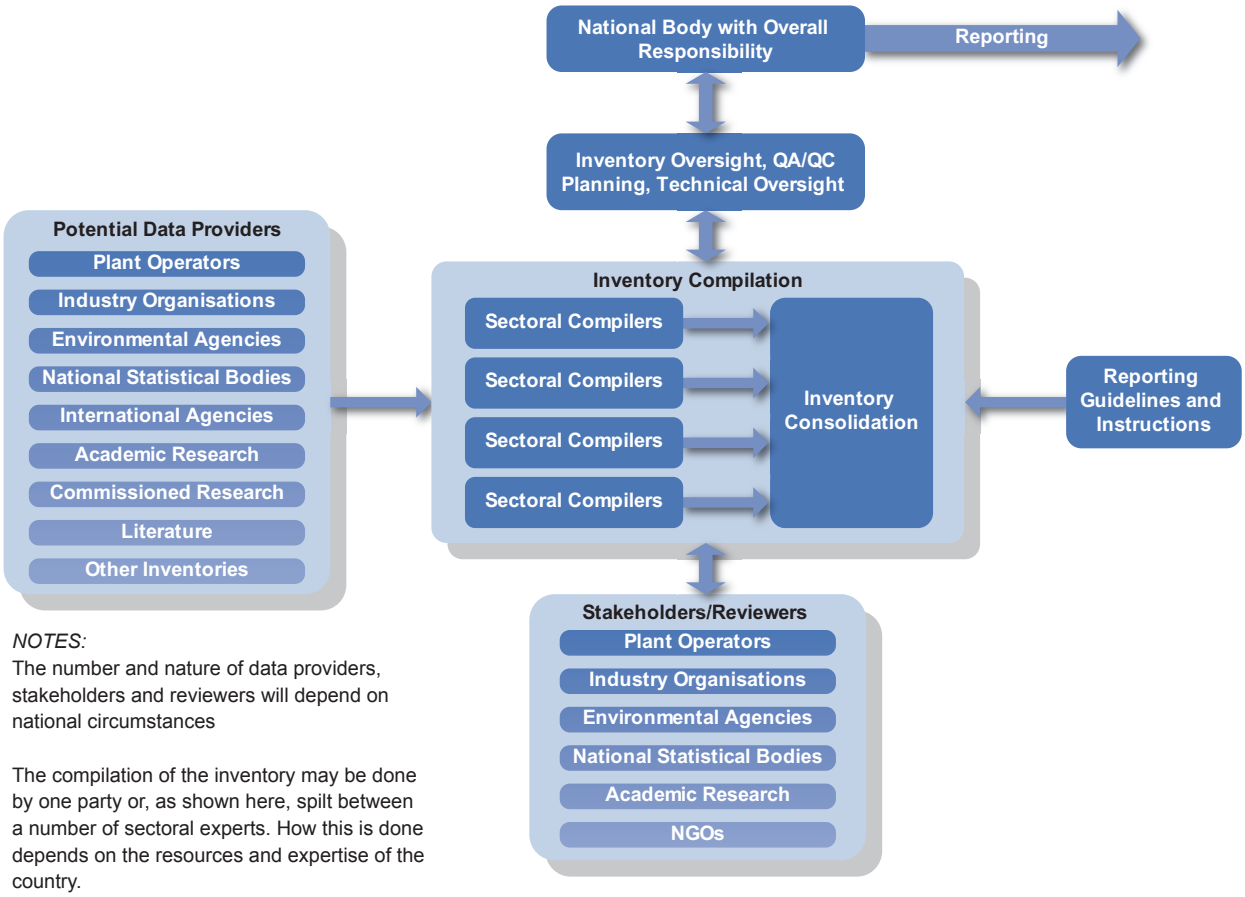

Figure 2 - National inventory compilation requires careful planning to link all those involved so that the result is accurate and timely.

Extensive reference is made to existing guidance provided by other organisations. Sources of data are varied and range from existing national and international statistics to specially commissioned data collection exercises.

Regular communication and consultation with providers of data is recommended throughout the inventory activities (from data collection to final reporting). This communication will build working relationships between data supplier and inventory compilers that will benefit the inventory both in terms of efficiency and quality. This activity will also help to keep the inventory compilers informed of the development of new datasets and even provide opportunities to influence the planning and specifications of data collection activities.

Uncertainty assessment: Uncertainty estimates provide valuable information, both to the inventory compilers, and to users of the inventory. Inventory compilers can use this information to help decide where to focus resources on improving the inventories. Estimates of uncertainty are needed for each source and sink category and greenhouse gas as well as inventory totals and their trends. Practical guidance for estimating and combining uncertainties, along with a discussion of the conceptual underpinnings of inventory uncertainty is given (Vol.1 Ch3). Uncertainty assessment is an important component of *good practice* in national greenhouse gas inventory development. The uncertainty analysis characterises the range and likelihood of possible values for the national inventory as a whole as well as for its components. Awareness of the uncertainties of parameters and results provides inventory compilers with insight when evaluating suitable data for the inventory during the data collection and compilation phases. Uncertainty assessment also helps identify the categories that contribute most to the overall uncertainty, which helps the inventory compiler prioritise future inventory improvements.

Key category analysis: An important part of *good practice guidance* is how to identify those sources and sinks that are *key categories*. The *key category* concept is used, together with the decision trees, to guide users in their

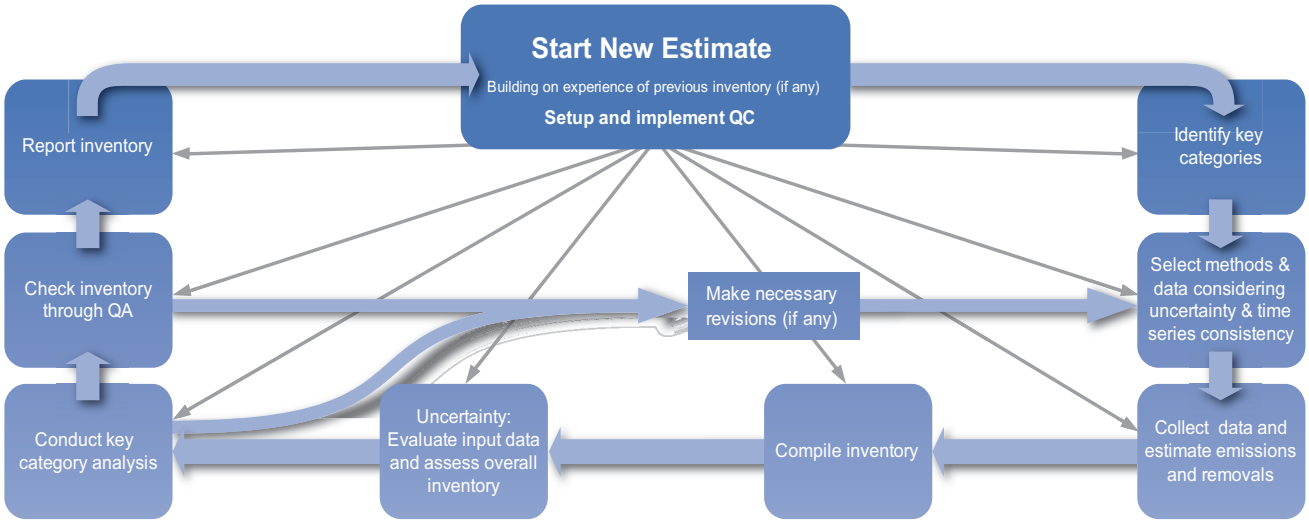

Figure 3 - Inventory production cycle

methodological choice for each category.

Time series consistency: Ensuring the time series consistency of inventories is essential for establishing confidence in reported inventory trends. Methods are provided for ensuring time series consistency in cases where it is not possible to use the same method and/or data over the entire period. New inventories may recalculate data for earlier years and the way this is done needs to be consistent with the *good practice guidance* in order to ensure that the new numbers are transparent, complete, consistent, comparable and accurate: in other words convincing to users of the resulting inventories.

Quality Assurance (QA) and Quality Control (QC): A QA/QC system is an important part of inventory development. The general and sector-specific QA/QC ellements to consider when compiling an inventory include planning, checks, documentation, verification and review. The *2006 Guidelines* encourage continuous improvement and rigor through QA/QC and verification activities. A number of concepts and tools (Vol.1 Ch.6) are provided to support efficient inventory management, checking and continuous improvement. These activities will achieve the best use of limited resources, and a quality consistent with *good practice,* for each inventory.

Reporting: Communicating the final emission inventory in a clear and convincing manner is important. Clear reporting guidance is provided to ensure that individual inventories are transparent and comparable. Transparent reporting, with sufficient background information, greatly increases the credibility of any inventory. Notation keys are provided to increase completeness and transparency in reporting, where numerical data cannot be provided. Reporting tables also cover *uncertainties*, *key category* analysis, and emission trends.

Volume 1 and Volumes 2 to 5 are complementary. After the compilers tasked with preparing estimates for specific emission and removal categories have familiarised themselves with the general guidance in Volume 1 they should use the specific sectoral volume(s) appropriate to their categories so that they can apply the requirements in a manner suitable to their national circumstances.

Step-by-step Inventory Compilation

Each stage of the production of emission inventories is described in the *2006 Guidelines*. Ideally, inventory compilation is a cyclic process, with each new year's inventory building on the previous years data (see Figure 3). Thus improvements to the inventory build up over time so that, even though resources are usually limited, emission inventory quality continuously improves. Quality control measures should be implemented at each step and should be documented according to the requirements of QA/QC and documentation given in Volume 1 Chapter 6.

1. The first step for a revised or new greenhouse gas inventory is to identify the *key categories* for the inventory so that resources can be prioritised. Where an inventory already exists, the *key categories* can be identified quantitatively from the previous estimates (Vol.1 Ch.4). For a new inventory the compilers have two choices. Firstly, they can make a preliminary qualitative assessment based on local knowledge and expertise

about large emission sources and inventories in countries with similar national circumstances. Or, secondly, they can make preliminary Tier 1 estimates to assist in identifying *key categories*.

Assessing the *key categories* helps the inventory compiler to focus effort and resources on the categories that contribute most to the overall inventory or inventory uncertainty and so helps to ensure that the best possible inventory is compiled for the available resources.

2. Once the *key categories* have been identified, the inventory compiler should identify the appropriate method for estimation for each category in the particular country circumstances. The category-specific decision trees in Volumes 2-5 and the generalised decision tree in Chapter 4 of Volume 1, provide guidance on selecting appropriate methods. The selection of methods will be determined by the classification of a category as *key* or not *key*, and by both the data and the resources available. Guidance on data collection is provided in Chapter 2 of Volume 1.
3. Data collection should follow the selection of the appropriate methods. (However it must be remembered that the data collection activities may reveal new data or difficulties in data that was thought to exist and so the choice of method may need to be revised in light of this information.) Data collection activities should consider the need for time series consistency and so data for a single year is less useful. Data on uncertainties should, if possible, be collected at the same time. (Vol.1 Chs.2 & 3)
4. Emissions and removals are estimated following the methodological choice and data collection. Care should be taken to follow the general guidance on time series consistency (Vol.1 Ch.5) especially if the data are incomplete for some years.
5. Once the inventory estimates are complete, the next step is to perform an uncertainty analysis and key category analysis (Vol.1 Chs.3 & 4). These analyses may identify categories for which a higher tier should be used and additional data collected.
6. Following the completion of the inventory final quality assurance (QA) checks need to be performed. These checks are an extremely important stage and should encompass review by stakeholders as well as parties outside the inventory process. Figure 4 shows an example of an annual inventory review cycle. This is a mature inventory system where the review phase is longer than the compilation phase and this reflects the importance of the review step.
7. The final step in the inventory process is to report the inventory (Vol.1 Ch. 8). The aim here is to present the inventory in an as concise and clear way as possible to enable users to understand the data, methods and assumptions used in the inventory. Provision of concise relevant background information and explanations in the accompanying reports helps to ensure the inventory is transparent.

   The compilers should base future inventory revisions on previous inventories. Thus an iterative process builds on and improves the inventory each time a new inventory is compiled as illustrated in Figure 3. When a new year's inventory is compiled, estimates for all years should be reviewed and updated, where necessary, integrating any feasible improvements.

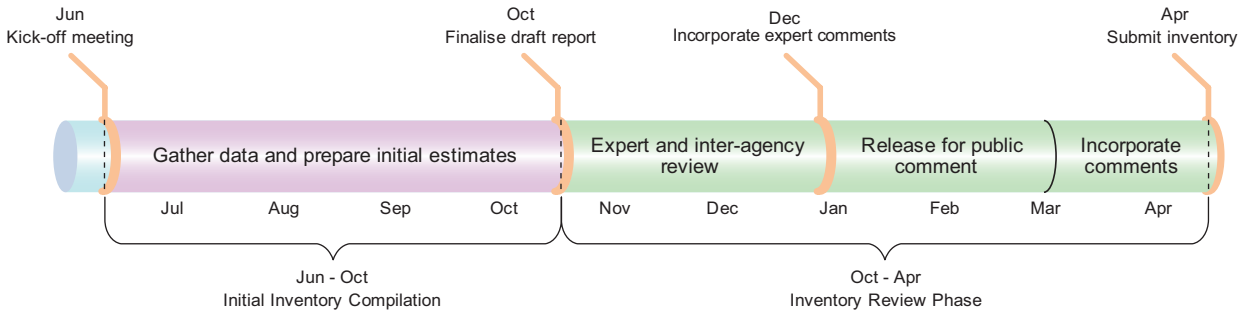

Figure 4 - An illustration of the timing of an annual inventory process

Box 1 - Using the flow diagram (Figure 3) and the 2006 Guidelines – Livestock example

Inventory compilers tasked with preparing estimates for specific categories need to familiarise themselves with guidance in two volumes: the relevant guidance in a sectoral volume (e.g., Volume 4, Agriculture, Forestry and Other Land Use), and the general guidance in Volume 1. Along with the diagram (see Figure 3) this box describes how the guidance in the two Volumes is used for estimating methane emissions from Enteric Fermentation:

Start with your previous inventory where available and prioritise categories for estimation.
The inventory compiler can begin with the overall results of the previous national inventory, particularly the key category assessment, as a preliminary step to selecting methods and data in Chapter 4 of Volume 1.

Familiarise yourself with general and sector specific QA/QC requirements.
Prior to collecting all the data and estimating emissions, the inventory compiler should consult the general guidance in implementing Quality Control (QC) procedures in Chapter 6 of Volume 1 (QA/QC and Verification) along with the specific QC procedures for enteric fermentation described in Chapter 10 of Volume 4. QC procedures should be implemented at every step of the inventory cycle. This will include regular checking and clear documentation of data sources, methods and assumptions.

Choose appropriate methods based on category importance and data availability.
The inventory compiler should consult the decision tree and methodological guidance in Chapter 10 of Volume 4 to select an appropriate method. In this example, enteric fermentation is a key category, which indicates that normally Tier 2 or 3 should be selected.

The general guidance in Chapter 2 (Approaches to Data Collection) of Volume 1 and Chapter 10 of Volume 4 will guide the inventory compiler in choosing appropriate emission factor, activity data and other estimation parameters. This may include identifying or choosing from existing data or collection and classification of new data.

Collect the data necessary for the latest year and a consistent time series and uncertainty estimation.
The next step involves collection of the needed data for all years. The availability of data may sometimes restrict use of higher tier methods for key categories.

Chapter 5 (Time Series Consistency) of Volume 1 should be used if preparing estimates for more than one year. This guidance is particularly relevant if the selected method is different from the one used in previous inventories or the sources of data or their classification have changed. This can imply the need for recalculations of previous estimates or splicing of data series. Chapter 10 of Volume 4 should be consulted for category-specific guidance on time series consistency.

In estimating uncertainties, inventory compilers should also refer to the general guidance on uncertainty in Chapter 3 of Volume 1 - paying particular attention to guidance on concepts and methods – and the uncertainty section of the enteric fermentation livestock chapter for source-specific information (for example default uncertainties). Ideally, the inventory compiler should collect activity data, emission factors, and uncertainty information at the same time because this is the most efficient strategy.

Estimate emissions/removals consistent with the guidance.
The next step is to estimate methane emissions from enteric fermentation for all relevant years. Relevant guidance for this step includes the specific guidance for enteric fermentation in Volume 4, Chapter 10 relating to completeness, reporting and documentation, and time series consistency sections.

The enteric fermentation emissions and uncertainty data are used subsequently as input into the compilation of the overall inventory, the estimation of category-specific and overall uncertainty, and the key category assessment. The results of these steps may require changes or revisions to the original estimate of emissions of enteric fermentation.

Check and review the estimates.
Following the Quality Assurance (QA) guidance in Chapter 6, Volume 1, the inventory compiler should arrange for review of the estimate and documentation by technical experts not involved in the preparation of the inventory. External reviewers may suggest improvements or identify errors that would require a recalculation of the enteric fermentation estimate.

Report the estimates.
The *IPCC Guidelines* provide guidance on reporting information on enteric fermentation in two places: the enteric fermentation chapter of Volume 4, and the reporting tables in Chapter 8 of Volume 1. The inventory compiler should consult both chapters for a complete description of reporting guidance.

Note: In the case of an initial inventory effort, with no previous key category analysis, a qualitative assessment of enteric fermentation could be used. See Chapter 2 and Chapter 4 of Volume 1. In this example, it can be concluded that methane from enteric fermentation is key in most inventories and should therefore initially be considered key.

TRANSITION FROM THE 1996 GUIDELINES

General Issues

This section outlines a number of issues that need to be considered in moving from using the *Revised 1996 Guidelines*, the *GPG2000* and the *GPG-LULUCF* to the new *2006 Guidelines*. The following section discusses the changes in the classification of the inventories.

The timing of the requirement to use the *2006 Guidelines* under the UNFCCC will depend on decisions by the Conference of the Parties. Meanwhile, the *2006 Guidelines* contain scientific information that may be useful for the implementation of the methodologies in the *Revised 1996 Guidelines*, the *GPG2000* and the *GPG-LULUCF*. It is the responsibility of countries to ensure that using the *2006 Guidelines* in this way is appropriate, and in particular does not introduce inconsistencies in the inventory time series.

Although the entire guidelines have been reviewed and updated, the methodological guidance is substantially unchanged since the *Revised 1996 Guidelines*. Where guidance has not been changed methods and default data have been reassessed to ensure they represent the most up-to-date information possible.

New default values are given in many categories. Where default methods have been used these will need to be checked and either the new defaults or country specific values used.

Structural changes

Although the number of sectors in the *2006 Guidelines* has been reduced from six to four this is not accompanied by any great changes at the individual category level. The *GPG-LULUCF* introduced a new approach for the "Land Use, Land-Use Change and Forestry" (LULUCF) Sector with a new classification of these categories. The *2006 Guidelines* maintain this structure, though now the LULUCF Sector has been combined with the Agriculture Sector to form the "Agriculture, Forestry and Other Land Use" (AFOLU) Sector.

This integration removes the somewhat arbitrary distinction between these categories (agriculture is, after all, a land use) in the previous guidance, and promotes consistent use of data between them, especially for more detailed methods. The Industrial Processes and Solvent and Other Product Use Sectors have also been combined into the Industrial Processes and Product Use (IPPU) Sector. These changes, in themselves, will not alter total emission estimates but should reduce errors and inconsistencies.

Improved general guidance

The *2006 Guidelines* introduce systematic cross-cutting advice on data collection from existing sources and by new activities, including design of measurement programmes. General principles and guidance are provided on the use of *key category* analysis and methodological choice. 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.

New gases and sources

The *2006 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. Also methane from abandoned coal mines, carbon dioxide capture and storage (CCS), biological treatment and open burning of waste (e.g.,composting and biogas facilities) are now included. The following sections provides details. Additional greenhouse gases identified in the IPCC Third Assessment Report (Climate Change 2001, IPCC 2001b) are also included where anthropogenic sources have been identified (see Table 1).

Estimation of actual annual emissions

In the *1996 Revised Guidelines* and *Good Practice Guidance* for a few sources, the simplest methodology estimates a "potential emission" rather than the actual annual emission. This "potential emission" assumes all the emissions from an activity occur in the same year, ignoring the fact they will occur over many years (e.g., methane emissions from waste in landfills occurs over decades as the decay processes take place).

In the *2006 Guidelines*, simple default methods have been devised to estimate emissions when they occur, thus removing the need for potential emissions. This also allows the emission reductions of abatement techniques to be properly estimated and ensures that the Tier 1 methods are compatible with higher tier methods. The areas where this occurred are:

Actual emissions of fluorinated compounds: The Tier 1 methods proposed 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.

Methane from landfills: A simple first order decay model that

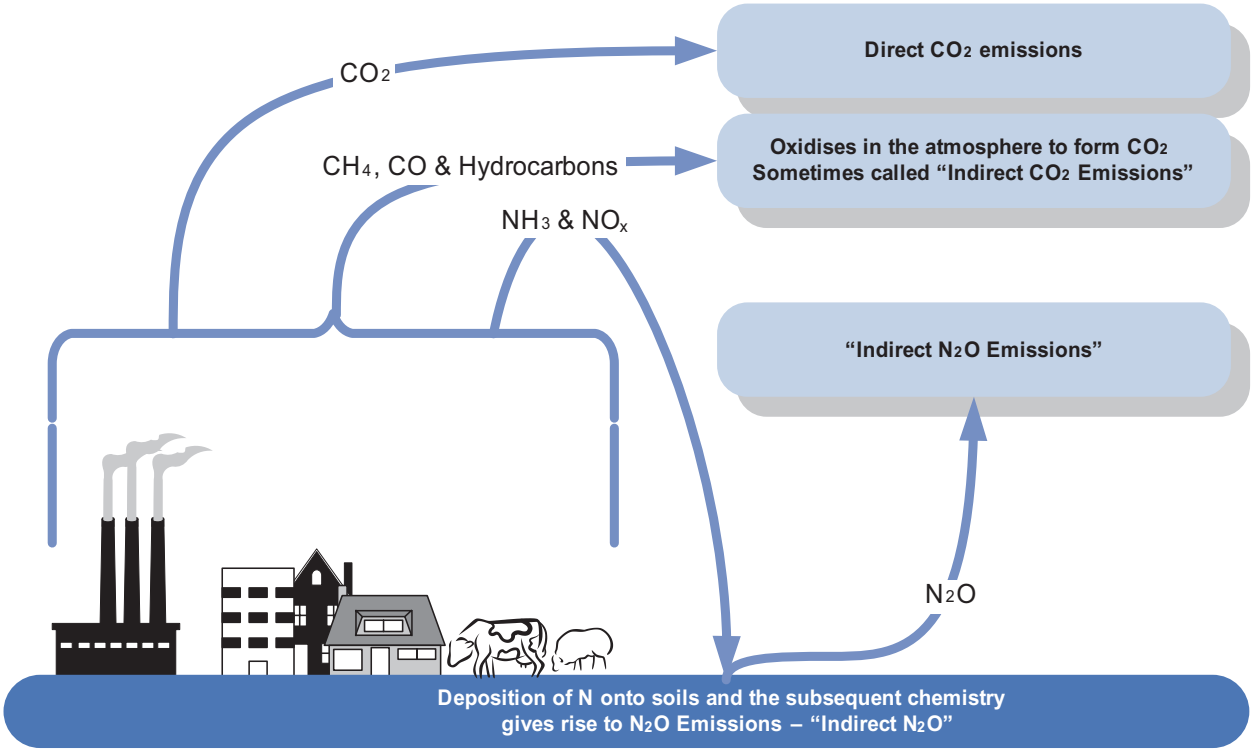

Figure 5 - Direct CO_2 and Indirect N_2O

provides the option to use data available from the UN and other sources has been adopted. This approach includes regional defaults and country-specific data on waste generation, composition and management, and provides a consistent basis for estimating greenhouse gas emissions across all tiers.

Reference Approach and Sectoral Approach for Energy Use: The *2006 Guidelines* clarify that it is the sectoral approach (based on fuel consumption by fuel type and user) that should be used for estimating emissions. The Reference Approach (based on national energy balances at a summary level) should be used as a QA/QC check for this important emission sector.

Direct CO_2

Not all carbon released to the atmosphere is emitted as CO_2; some is emitted as CH_4, CO or a range of hydrocarbons. 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 (see Figure 5). The *2006 Guidelines* estimate emissions in terms of the species which are actually emitted: therefore the total CO_2 addition to the atmosphere will be the CO_2 emissions *plus* the CO_2 resulting from other gases, which can be calculated using the *2006 Guidelines*. In some cases the emissions of these non-CO_2 gases contain very small amounts of carbon compared to the CO_2 and, for the simplest Tier 1 methods, CO_2 estimates can be based on the total carbon as this simplifies the calculations and data collection without significantly worsening the accuracy.

The *Revised 1996 Guidelines* are, in fact, inconsistent on this issue and the *2006 Guidelines* have attempted to clarify it.

Indirect N_2O

The *Revised 1996 Guidelines* and *GPG2000* list sources of anthropogenic nitrogen deposition that subsequently give rise to anthropogenic emissions of N_2O (see Figure 5). However, they only provide estimation methods for some agricultural sources of NH_3 and NO_x. The *2006 Guidelines* extend this approach to all significant sources of N deposition, where these are already estimated, including agriculture, industrial and combustion sources, with the ultimate N_2O emission attributed to the country responsible for the nitrogen originally emitted.

Carbon Dioxide Capture and Storage

The impact of Carbon dioxide Capture and Storage (CCS) is 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 are consistent with the IPCC Special Report on Carbon Dioxide Capture and Storage (IPCC 2005). Amounts of CO_2 captured from combustion of biofuels, and subsequently injected into underground storage are included in the inventory as a "negative emission" so that no distinction is needed between any subsequent leakage of this CO_2 and that of CO_2 from fossil sources.

Non-Energy Uses of fossil fuels

Guidance on demarcation between the Energy and Industrial Processes and Product Use Sectors has been improved, and emissions from non-energy uses of fossil fuels are now reported under IPPU, rather than in Energy. A method has been introduced for checking the completeness of carbon dioxide emission estimates from the non-energy uses.

AFOLU - Consolidation of previously optional categories

Fluxes of gases 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. 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 Guideline*s, unless the disturbance is followed by a land-use change. 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

Harvested Wood Products (HWP) includes all products made from wood such as paper, packaging, books, furniture and houses, and is a store of carbon removed from forests. The *2006 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. Carbon from HWP accumulating in landfills is provided as an output from the decay models, and may be useful for the estimation of HWP in AFOLU.

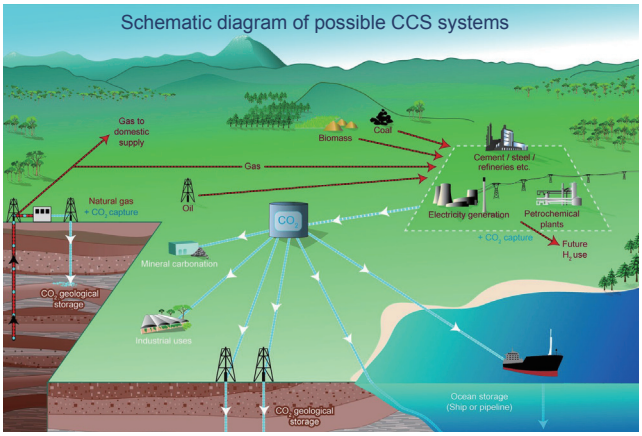

Figure 6 - Carbon dioxide capture, storage and transport (Source: IPCC(2005))

Wetlands

The *2006 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.

Changes in Categorisation

This section provides details of the differences between the source/sink categorisation in the *Revised 1996 Guidelines* and *Good Practice Guidance* and the new *2006 Guidelines*. Most of the changes are the result of either new source/sink categories being added; existing categories being sub-divided to provide more transparency or due to the consolidation of previously separate sectors into the new IPPU and AFOLU Sectors.

In the IPPU Sector there are many new source categories included and the restructuring has resulted in some of the source categories being presented in a different order. However, for the inventories compilers perspective, moving from the Revised 1996 Guidelines classification to the 2006 Guidelines classification should be straightforward.

For AFOLU the differences between the *2006 Guidelines* and the *GPG-LULUCF* are small with the inclusion of agriculture requiring a re-numbering of category codes. Inventory compilers already using the *Good Practice Guidance* should have no problems. However, moving from the 1996 classification to the GPG-LULUCF classification is a major step as it is based on land use types rather than processes.

Energy

In the Energy Sector the changes are minimal. Table 3 lists the main changes.

There are two new sources have been added (*Urea-Based Catalysts* and *Carbon Transport and Storage*) and provision for more detail in Stationary Combustion has been made in 1A2 and 1B2.

Table 3 - Energy
Main changes in Guidelines Classification

Revised 1996 Guidelines	2006 Guidelines	Notes
1A2f Fuel Combustion - Manufacturing Industries and Construction - Other	1A2f – 1A2m	Split into Non-metallic Minerals, Transport Equipment, Machinery, Mining and Quarrying, Wood and Wood Products, Construction, Textile and Leather, Other
	1A3bvi Urea-based Catalysts	New sector - Emissions from road transport equipped with urea-based catalysts
1A5b Fuel Combustion - Non-Specified	1A5b, 1Abi, 1A5bii, 1A5biii, 1A5c	Non-specified sector sub-divided in 2006 Guidelines, added a specific sector 1A5c for multilateral operations (emissions not included in national totals)
1B2 Fugitive Emissions from Fuels - Oil and Natural Gas	1B2	This has been structured by the authors to facilitate reporting with venting and flaring included under oil or natural gas as appropriate instead of being separate.
	1B3 Other emissions from energy production	Other emissions from energy production – category provided to have somewhere to report unusual emissions such as geothermal sources.
	1C Carbon Transport and Storage	New sector – Carbon Capture and Storage (CCS) emissions reported here.

IPPU

In IPPU, the whole sector has been restructured. The table lists the categories that are in the *2006 Guidelines* that were not present in the *Revised 1996 Guidelines*: some were previously included in other categories while for the others new guidance is provided.

Another change is that, more logically, emissions from the Non-Energy Use of fuels are made in this Sector rather than in the Energy Sector. (See guidance in Vol.3 Ch.5)

Differing from the *Revised 1996 Guidelines*, in the *2006 IPCC Guidelines*, emissions from the use of carbonates should be reported in the sub-categories (industries) where they occur. Therefore part of the emissions that were reported in 2A3 and 2A4 under the *Revised 1996 Guidelines* should be reported in different categories (e.g., 2C1) in the *2006 IPCC Guidelines*. Also, CO_2 used in urea production should be deducted from CO_2 emissions from ammonia production, while it was not the case according to the *Revised 1996 Guidelines*. In the *2006 IPCC Guidelines*, CO_2 emissions from downstream use of urea should be reported where they occur (e.g., in Agriculture sector for urea use as fertilizer, or road transport for urea-based catalysts).

Table 4 - Specific IPPU Categories not in the Revised 1996 Guidelines

2006 Guidelines Category Code	Category Name
2A3	**Glass Production**
2A4a	**Ceramics**
2A4c	**Non Metallurgical Magnesia Production**
2B4	**Caprolactam, Glyoxal and Glyoxylic Acid Production**
2B6	**Titanium Dioxide Production**
2B8	**Petrochemical and Carbon Black Production**
2B8a	*Methanol*
2B8b	*Ethylene*
2B8c	*Ethylene Dichloride and Vinyl Chloride Monomer*
2B8d	*Ethylene Oxide*
2B8e	*Acrylonitrile*
2B8f	*Carbon Black*
2C5	**Lead Production**
2C6	**Zinc Production**
2D	**Non-Energy Products from Fuels and Solvent Use**
2E1	*Integrated Circuit or Semiconductor*
2E2	**TFT Flat Panel Display**
2E3	**Photovoltaics**
2E4	**Heat Transfer Fluid**
2F	*Product Uses as Substitutes for Ozone Depleting Substances*
2G1a	*Manufacture of Electrical Equipment*
2G1b	*Use of Electrical Equipment*
2G1c	*Disposal of Electrical Equipment*
2G2a	**Military Applications**
2G2b	**Accelerators**
2G3a	**Medical Applications**
2G3b	**Propellant for Pressure and Aerosol Products**

Note: Categories in **Bold font** were not in the 1996 Guidelines while for those in *italic font* guidance was provided but were not reported separately.

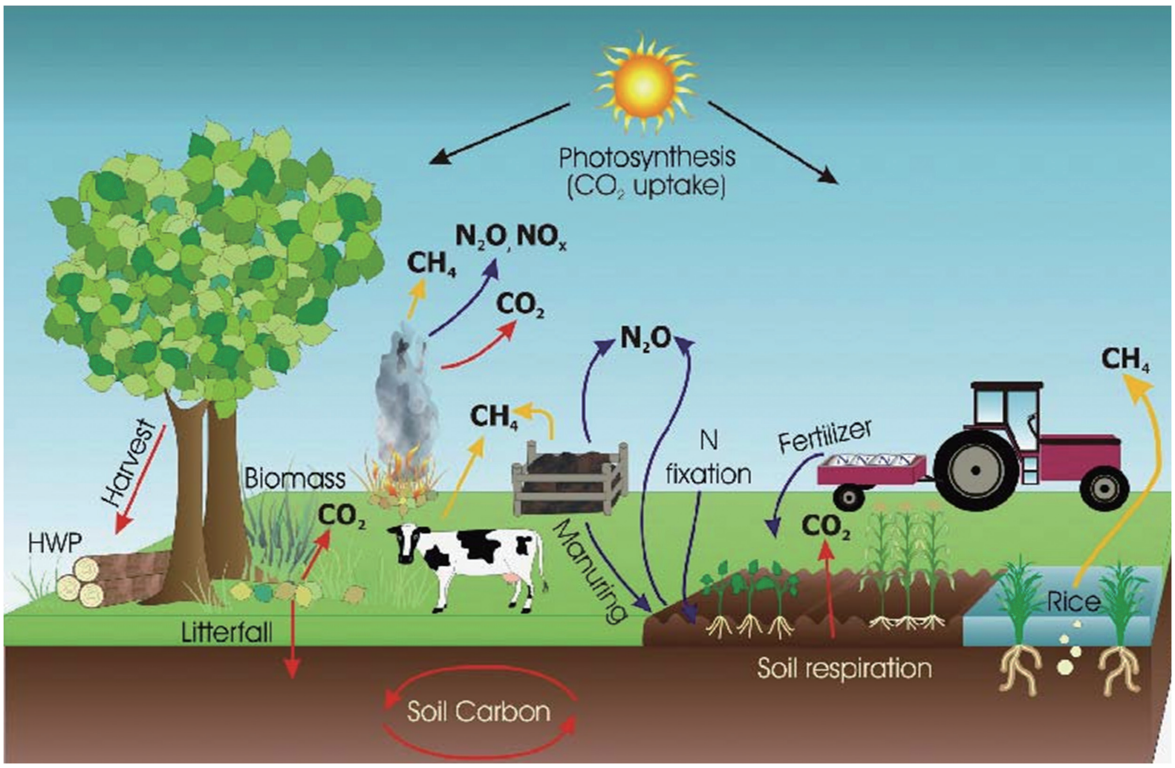

Figure 7 - Overview of the AFOLU Sector

AFOLU

Livestock Emissions are now reported in category 3A1 and 3A2 (instead of 4A and 4B in the *Revised 1996 Guidelines*) with the same breakdown. The Manure Management categories, 4B10 *Anaerobic*, 4B11 *Liquid Systems* and 4B12 *Solid Storage and Drylot* in the *1996 Revised Guidelines* have been deleted with emissions reported under the appropriate animal type.

Emissions/removals from land use and land-use change are reported in 3B in the same way as for the good practice guidance (*GPG-LULUCF*).

Remaining emissions from AFOLU are reported in categories 3C and 3D – see Table 5.

See *2006 Guidelines* Volume 4 on estimating and reporting emissions from fires on managed lands as this differs for earlier guidelines (all fires on managed land should now be reported).

Reporting of *Harvested Wood Products* depends on the approach chosen (see Vol.4 Ch.12).

Table 5 - AFOLU - 3C & 3D

2006 IPCC Guidelines Category Code	Category Name	Revised 1996 Guidelines
3C	Aggregate Sources and Non-CO_2 Emissions Sources on Land	
3C1	Emissions from Biomass Burning*	
3C1a	Biomass Burning in Forest Lands*	5B
3C1b	Biomass Burning in Croplands*	4F
3C1c	Biomass Burning in Grasslands*	4E, 5B
3C1d	Biomass Burning in All Other Land*	
3C2	Liming*	5D
3C3	Urea Application	
3C4	Direct N_2O Emissions from Managed Soils*	4D
3C5	Indirect N_2O Emissions from Managed Soils*	4D
3C6	Indirect N_2O Emissions from Manure Management	
3C7	Rice Cultivations*	4C
3C8	Other (please specify)	
3D	Other	
3D1	Harvested Wood Products*	
3D2	Other (please specify)	4G & 5E

* Guidance was provided in GPG2000/GPG-LULUCF

Waste

Solid Waste Disposal has been subdivided for ease of reporting with the addition of 4A3 for *Uncategorised Waste Disposal Sites*. Guidance on *Open Burning of Waste* (4C2) has been included and can now be reported separately from incinerators. Guidance on *Biological Treatment of Solid Waste* (4B) is included for the first time and separated from *Solid Waste Disposal*.

Other

Emissions that do not fit into the four sectors should be reported under 5 *Other*. Emissions of N_2O resulting from *the deposition of non-agricultural sources of* NO_x *and* NH_3 should be reported under 5A.

Table 6 - Waste Sector

2006 Guidelines Category Code	Caetgory Name	Revised 1996 Guidelines
4	WASTE	6
4A	Solid Waste Disposal	6A
4A1	Managed Waste Disposal Sites	6A1
4A2	Unmanaged Waste Disposal Sites	6A2
4A3	Uncategorised Waste Disposal Sites	
4B	Biological Treatment of Solid Waste	
4C	Incineration and Open Burning of Waste	6C
4C1	Waste Incineration	6C
4C2	Open Burning of Waste	
4D	Wastewater Treatment and Discharge	6B
4D1	Domestic Wastewater Treatment and Discharge	6B2
4D2	Industrial Wastewater Treatment and Discharge	6B1
4E	Other (please specify)	6D

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