

United Nations Framework Convention on Climate Change

UNFCCC RESOURCE GUIDE

**FOR PREPARING THE
NATIONAL COMMUNICATIONS
OF NON-ANNEX I PARTIES**

**MODULE 3
NATIONAL GREENHOUSE GAS
INVENTORIES**



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MODULE 3:

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I. INTRODUCTION

1.1 GREENHOUSE GASES AND CLIMATE CHANGE

The UNFCCC defines climate change as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. Human activities are changing the atmospheric concentrations and distributions of greenhouse gases (GHGs) and aerosols (i.e. airborne solid or liquid particles). These changes can cause radiative forcing by changing the reflection or absorption of solar radiation, or the absorption or emission of terrestrial radiation (IPCC 1996). The objective of a national GHG inventory is to determine the magnitude of national GHG emissions and removals that are directly attributable to human activity.

As required by decision 17/CP.8, each Party not included in Annex I to the Convention (Non-Annex I Party) shall, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass, estimates of anthropogenic emissions of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) by sources and removals by sinks. Non-Annex I Parties are encouraged, as appropriate, to provide information on anthropogenic emissions by sources of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆).

1.2 ABOUT THE MODULE

This module was developed as a guide to assist non-Annex I Parties in the preparation of the GHG inventories for their national communications. It forms part of the *Resource Guide for Preparing the National Communications of Non-Annex I Parties* (hereinafter referred to as the Resource Guide).¹ It aims to provide a brief overview of some of the main methods, tools and data being used by non-Annex I Parties to prepare their national GHG inventory. After reading this module, readers should be able to understand a number of key issues related to GHG inventories, including sector-specific emission estimation considerations.

1.3 MAIN SOURCES OF RELATED INFORMATION

Main sources of information used throughout the module are listed below. Further sources are also provided where relevant, within each section.

- *Reporting on Climate Change: User Manual for the Guidelines on National Communication from Non-Annex I Parties*²
- *Intergovernmental Panel on Climate Change (IPCC) Methodologies for National GHG Inventories*³
- *Managing the National Greenhouse Gas Inventory Process: National Communications Support Unit Handbook*;⁴
- Materials for the hands-on training workshops of the Consultative Group of Experts on national communications from Parties not included in Annex I to the Convention (CGE) (hereinafter referred to as the CGE GHG Inventory Handbook).⁵

¹ Available at <http://unfccc.int/essential_background/background_publications_htmlpdf/items/2625.php>.

² Available at <http://unfccc.int/national_reports/non-annex_i_natcom/guidelines_and_user_manual/items/2607.php>.

³ Available at <<http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html>>.

⁴ Available at <<http://ncsp.undp.org/docs/461.pdf>>.

⁵ Available at <http://unfccc.int/resource/cd_roms/na1/start.htm>.

II. WHAT IS A NATIONAL GREENHOUSE GAS INVENTORY?

A national GHG inventory is a key element of the national communication. In the context of the UNFCCC, it is a comprehensive listing, by source, of annual GHG emissions and removals resulting directly from human activities. An inventory may estimate emissions and removals for one year or a number of years. A GHG inventory could contain the following information:

- Tables of annual emission and removal estimates by source, with estimates expressed in units of mass per year, and the year or years represented clearly noted;
- Worksheets (i.e. calculation sheets) showing how emissions are calculated, including all parameters used for calculations;
- For each source, a description of the methodology, the sources of data (e.g. activity data, emission factors (EFs), methodologies), the actual data and a description of uncertainties, including, if possible, quantitative assessment of uncertainties; and
- Other informative background data (e.g. a national energy balance, a description of GHG sources that are believed to be important but cannot be estimated).

The IPCC inventory guidance applicable to non-Annex I Parties (IPCC Guidelines: 1997, 2000 and 2003) defines six inventory sectors: *Energy; Industrial Processes; Solvent and Other Product Use; Agriculture; Land Use, Land-Use Change and Forestry (LULUCF); and Waste*. *Nonetheless, no method for the calculation of GHGs from solvent and other product use is available*. Within these sectors, individual source and sinks categories are defined. Parties to the UNFCCC are required to report their inventories in line with the definitions and structure of these sectors, and the source and sink categories within each sector, so that reporting is comparable across Parties. Updated guidance for the development of national GHG inventories can be found in the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the 2006 IPCC Guidelines), although these are not yet adopted for use by Parties to the UNFCCC.

In order to ensure precision and reliability, national GHG inventories are required to fulfil certain criteria, as laid out in the *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (hereinafter referred to as the IPCC good practice guidance).⁶ Thus, the inventories must be transparent, consistent, comparable, complete and accurate (TCCCA). In the context of the UNFCCC “Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention” (hereinafter referred to as the UNFCCC reporting guidelines for non-Annex I Parties), and specifically the section addressing national GHG inventories:

- *Transparency* means that the assumptions and methodologies used for an inventory are 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;
- *Consistency* means that an inventory is internally consistent in all its elements with inventories of other years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. Under certain circumstances, an inventory using different methodologies for different years can be considered to be consistent if it has been recalculated in a transparent manner, in accordance with the IPCC good practice guidance;
- *Comparability* means that estimates of emissions and removals reported by Parties in their inventories are comparable;
- *Completeness* means that an inventory covers all sources and sinks, as well as all gases, included in the IPCC Guidelines, as well as other existing relevant source/sink categories which are specific to individual Parties and, therefore, may not be included in the IPCC Guidelines. Completeness also means full geographic coverage of sources and sinks of a Party;

⁶ Available at <<http://www.ipcc-nggip.iges.or.jp/public/gp/english/>>.

- *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, as far as can be judged, and that uncertainties are reduced as far as practicable.

According to the IPCC good practice guidance, inventory estimates should be the best attainable, given current scientific knowledge and available resources. The IPCC good practice guidance (i.e. 2000 and 2003) manuals assist countries in meeting these requirements by providing guidance on:

- Choice of *estimation method*;
- *Quality assurance* and *quality control* procedures to provide cross-checks during inventory compilation;
- *Data* and information to be *documented, reported* and *archived* to facilitate assessment of emission estimates;
- Quantification of *uncertainties* at the source level and for the inventory as a whole, so that the resources available for research can be directed toward reducing uncertainties over time, and the improvement can be tracked;
- Determination of the *most significant sources* so that appropriate decisions can be made about the allocation of resources for inventory improvements.

III. THE INVENTORY PROCESS

The outputs of the first component are an inventory workplan and the overall inventory preparation instructions. The output of the second component is the source(s) preparation instructions.

Each component of planning includes a set of tasks:⁷

3.1 PLANNING

There are two components to the planning process:

- Planning the overall preparation of the inventory;
- Planning the preparation of individual source and sink categories.

⁷ For more detailed information, see <http://ncsp.undp.org/docs/461.pdf>.

Figure III-1.

Steps for planning of GHG inventory

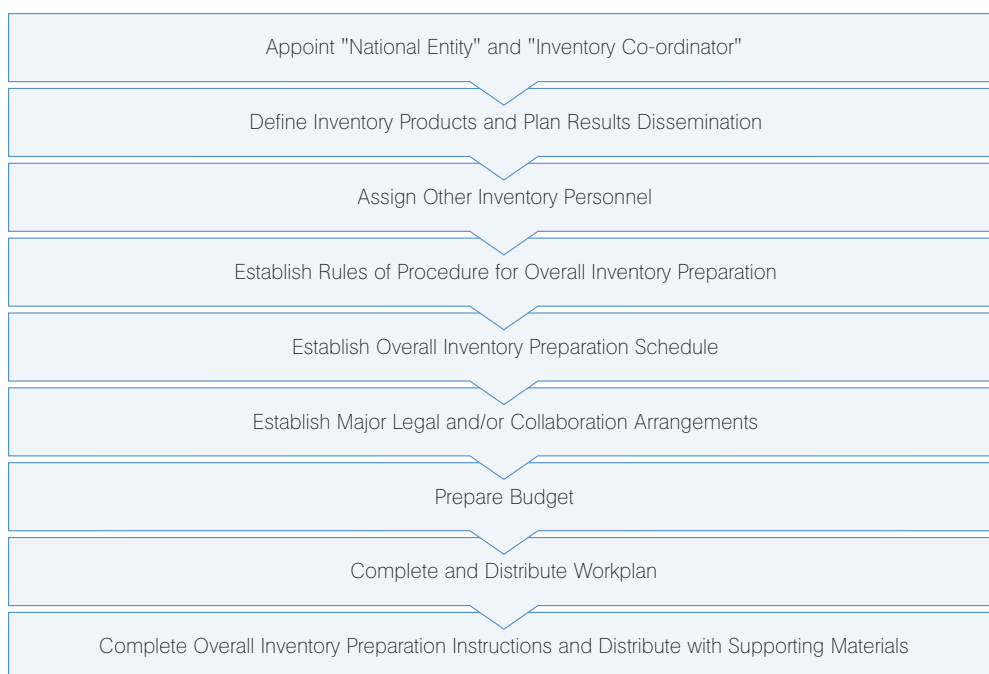
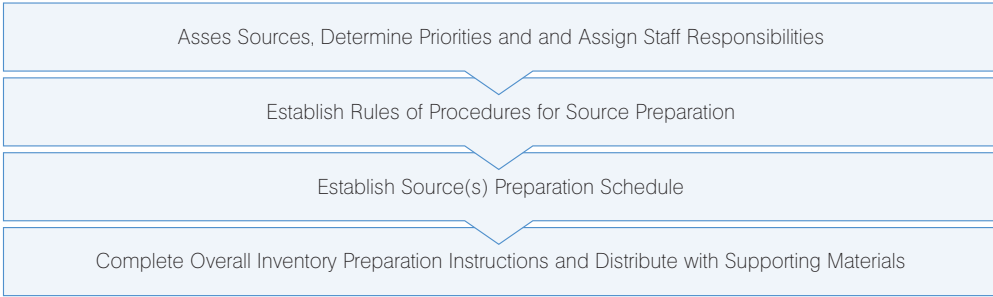


Figure III-2. Source-Specific Planning Tasks



Box III-1. Tasks in the Planning Phase⁸

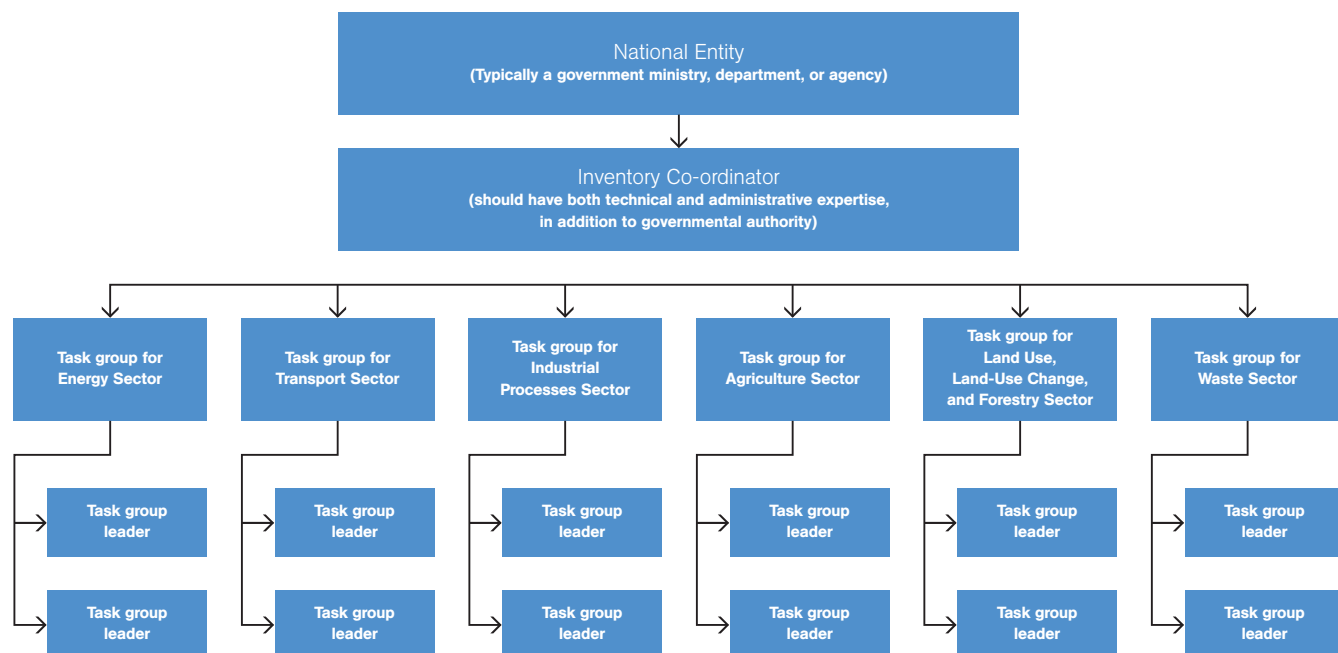
In general, inventory planning tasks will need to be completed before the category-specific planning tasks can begin. However, in cases where the inventory team is mature, i.e. the team has completed several versions of the inventory; the category-specific tasks may be started in parallel to with the overall inventory tasks.

Typically, the institution with the legal responsibility for producing the inventory, which is referred to here as the **“National Entity”**, will appoint an overall **“Inventory Coordinator”**, who oversees the entire inventory. The Inventory Coordinator is responsible for planning the overall preparation of the inventory (except the first task) and, as the inventory is prepared, provides overall coordination, management and technical oversight. In addition, there are individual **source(s) team leaders**, each of whom is responsible for inventory planning for his or her source(s), as well as overseeing the inventory preparation for his or her source(s).

During planning, the schedule for completion of the inventory and the procedures that are to be followed by category team leaders are set, and the resource budget is established. In some countries, category team leaders may have control over their own separate budgets. Therefore, the overall planning, in effect, drives the category-specific planning.

Completing both the inventory planning tasks and the category-specific planning tasks requires an understanding of not only how to administer a large and complex analytical process, but also the technical requirements of compiling a national GHG inventory. Therefore, the Inventory Coordinator and the category team leaders should possess both administrative and technical expertise. In addition, they should confer with one another throughout the planning process to ensure that the planning is internally coordinated, complete and logical.

Figure III-3. Possible structure for GHG inventory team



3.2 PREPARATION

3.2.1 EMISSIONS ESTIMATION

Once the inventory planning tasks have been performed and data collection is under way, it is time to begin the process of calculating emission estimations. In its most basic form, the method commonly used to estimate emissions or removals from a specific source category is as follows:⁹

Equation 1 – Emissions estimate

Emissions estimate = Activity data x Emission factor

where:

Activity data describe the annual, national magnitude of an activity (e.g. tonnes of coal mined nationally in a given year); and the Emission factor is the mass of GHG emitted per unit of activity (e.g. Gg CH₄ per tonne of coal mined).

In many cases, the activity data available are not exactly what is required given the particular emission factors that will be used. In these cases, the activity data must be derived by applying “conversion factors” to other data, which are referred to here as “proxy activity data”. In this case, the basic method is:

Equation 2 – Emissions estimate using proxy activity data

Emissions estimate =
[Proxy activity data x Conversion Factor(s)] x Emission

⁸ Managing the National Greenhouse Gas Inventory Process, page 9,

⁹ <http://ncsp.undp.org/docs/461.pdf>.

Except in cases where emission estimates are based on direct measurement.

3.2.2 TIERS

Different methods can be used to estimate emissions or removals from most source and sink categories. The selection of a particular method will depend on the desired degree of estimation detail, the availability of activity data and emission factors, and the financial and human resources available to complete the inventory. In IPCC terminology, the lowest ranking or simplest method is “Tier 1”, while more elaborate methods are “Tier 2” and “Tier 3.”

Tier 1 methods typically utilize IPCC default emission factors and require the most basic, and least disaggregated, activity data. Higher tiers usually utilize more elaborate methods and source-specific, technology-specific, region-specific and/or country-specific emission factors, which are often based on measurements, and normally require more highly disaggregated activity data. Tier 2 and 3 methods require more detailed data and/or measurements for their application. In cases where a national methodology exists, which is consistent with the IPCC Guidelines, it is highly advisable to use the national methodology. This methodology should be fully documented in order to allow the reader to understand why this particular method is better than the default one proposed by the IPCC.

3.2.3 GHG PROFILES

A GHG profile is a summary of most representative GHG data for a Party. It contains the following elements:

- Data table;
- Graph with trends for GHG totals;
- Graph with sectoral changes in GHG emissions;
- Graph with the GHG shares by gas;
- Graph with the GHG shares by sector;
- Graph with the GHG shares by category.

In order to allow the comparison of emissions between different years of the inventory, the GHG profile must be internally consistent; i.e. the methods, emission factors and assumptions should be the same for all inventory years. Ideally, the data sources used for activity data will be *the same for all years*.

3.2.4 UNCERTAINTY ANALYSIS

Proper estimates of uncertainty associated with GHG emission quantification are essential; not to dispute estimations, but to improve future estimations and allow for better comparison. The use of the IPCC good practice guidance is encouraged by the UNFCCC reporting guidelines for non-Annex I Parties in order to assess the uncertainty related to their national GHG inventories. The IPCC good practice guidance provides Parties with two tiers for combining individual source category uncertainties into an uncertainty estimate for the inventory as a whole, and identifies the following three sources of uncertainty:

- Uncertainties from definitions;
- Uncertainties from natural variability of the process that produces an emission or uptake;
- Uncertainties resulting from the assessment of the process or quantity, including, depending on the method used:
 - a) Uncertainties from measuring;
 - b) Uncertainties from sampling;
 - c) Uncertainties from reference data that may be incompletely described;
 - d) Uncertainties from expert judgement.

The IPCC good practice guidance provides extensive detail on both identifying uncertainties which may be associated with a national GHG inventory, and methods for estimating identified uncertainties for source categories, as well as the complete inventory.

3.2.5 RECALCULATIONS

An inventory may be recalculated for different reasons. Sometimes, improved methodologies, emission factors and/or activity data become available; e.g. as a result of new research or emission measurements. In addition, earlier estimates are sometimes found to have been based on wrong assumptions or miscalculations. If improved methods or emission factors are used, they should be used to recalculate the entire inventory time series. To avoid confusion, it is important to report and document recalculations clearly, including when recalculations were performed and which methods, emission factors and activity data were used in the different versions of the inventory.

3.2.6 KEY CATEGORIES

A key category is one that is prioritized within the national inventory system because its estimate has a major influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, or trends in emissions, or both. By identifying these key categories, Parties can prioritize their efforts and resources in order to improve their overall estimates. Such a process will lead to improved quality, as well as greater confidence in the emissions/removal estimates that are calculated. It is good practice for each Party to identify its national key categories in a systematic and objective manner.

3.3 REPORTING

One of the main purposes for compiling a national GHG inventory is to report to national or international entities. Reported information should be transparent and complete, with all the information required to produce the national inventory estimates documented and archived. It is not practical to include all this information in the inventory report; however summary information and references to source data could be included.

The IPCC good practice guidance is a beneficial tool, as it provides useful advice for selecting methods (tiered approaches), emission factors and activity data. Furthermore, it can aid the selection of appropriate methods and emission factors, the quantifying and analysis of uncertainty, the determination of key categories, the recalculation of emissions data, and the development of quality assurance and quality control plans.

The IPCC good practice guidance can be found at <http://www.ipcc-nggip.iges.or.jp/public/gp/gpgaum.htm>

3.4 DOCUMENTATION AND ARCHIVING

Once the GHG inventory and other components of the national communications are completed, the document(s) must be submitted to the Conference of the Parties (COP) in both hard copy and soft (electronic) format. The information must be submitted as a single document with an executive summary (maximum 10 pages) outlining the information contained in the full document. Non-Annex I Parties may submit their national communications in any of the official languages of the United Nations, but are encouraged to translate the document into English; however, the executive summary must be translated into English. Often, a Party will have additional information which supports or adds to the national communication; such documents may be submitted as technical annex(es) or as an addendum.

Once submitted to the UNFCCC, national communications from non-Annex I Parties are held by the UNFCCC and made publicly available through the Convention website.¹⁰

3.5 INVENTORY IMPROVEMENT STRATEGY

Improvements may arise from various aspects of the national communication process and, may or may not be, immediately feasible. In addition to sources of improvement which may be identified during the uncertainty assessment, non-Annex I Parties should describe any constraints and gaps and related financial, technical and capacity needs, associated with the implementation of activities and preparation and improvement of national communications.

¹⁰ http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php.

IV. SECTOR-SPECIFIC METHODOLOGIES

4.1 ENERGY

4.1.1 COMBUSTION

The Energy sector includes two major combustion-related activities:

- 1) Stationary combustion;
- 2) Transport or mobile combustion.

Each of these activities includes various sources that emit CO₂, CH₄ and N₂O.

Stationary combustion source categories include:

- Energy industries, which includes activities such as energy extraction, energy production and transformation, electricity generation, petroleum refining, etc. Emissions due to autoproduction¹¹ of electricity are included in this source category, and are attributed to the industrial categories in which the generation activity occurs;
- Manufacturing industries and construction, which includes activities such as iron and steel production, non-ferrous metal production, chemical manufacturing, pulp, paper and print, food processing, beverages and tobacco, etc.;
- Other sectors such as Commercial/Institutional, Residential, and Agriculture/Forestry/Fisheries.

Mobile source categories include:

- Civil aviation;
- Road transportation (cars, light duty trucks, heavy duty trucks and buses, motorcycles, etc.);
- Railways;
- Navigation;
- Other transportation activities, such as gas pipeline transport.

International bunker fuels, which include navigation and civil aviation fuel emissions from international transport activities (i.e. bunker fuels), should be reported separately and excluded from national totals.

Carbon Dioxide emissions result from the oxidation of the carbon in fuels during combustion. In perfect combustion conditions, the total carbon content of fuels would be converted into CO₂. However, real combustion processes are not perfect, and result in small amounts of partially oxidized and unoxidized carbon.

The carbon content of a fuel is an inherent chemical property (i.e. mass of carbon atoms relative to total mass of the fuel).

The energy content (i.e. calorific value or heating value) of fuels is also an inherent chemical property. However, calorific values vary more widely between and within fuel types, as they are dependent upon the composition of chemical bonds in the fuel. Given these variations and the relationship between carbon content and calorific values, carbon content values for estimating CO₂ emissions from fossil fuel combustion are expressed in terms of carbon per energy unit. This form generally provides more accurate emission estimates than if carbon content factors were expressed in terms of mass or volume, assuming reasonably accurate calorific values are available to convert fuel statistics into energy units.

Net calorific values (NCVs) measure the quantity of heat liberated by the complete combustion of a unit volume or mass of a fuel, assuming that the water resulting from combustion remains as a vapour, and the heat of the vapour is not recovered. In contrast, gross calorific values (GCVs) are estimated assuming that this water vapour is completely condensed and the heat is recovered, and are therefore slightly larger. Default data in the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (hereinafter referred to as the Revised 1996 IPCC Guidelines) are based on NCVs.

Due to incomplete combustion of hydrocarbons in fuel, small proportions of carbon are released as carbon monoxide (CO), CH₄ or non-methane volatile organic compounds (NMVOCs), all of which eventually oxidize to CO₂ in the atmosphere. In addition, combustion processes result in emissions of N₂O and nitrogen oxides (NO_x).

Unlike CO₂, emission estimates of CH₄, N₂O, NO_x, CO and NMVOCs require detailed process information. Accurate estimation of their emissions depends on knowledge of several interrelated factors, including combustion conditions, size and age of the combustion technology, maintenance, operational practices, emission controls, as well as fuel characteristics. The methods should be applied at a detailed activity/technology level so as to take, to the extent possible, these factors into account.

The reference approach (Tier 1) estimates only CO₂ emissions from fuel combustion. The reference approach for CO₂ can be performed quickly, provided that the basic energy balance sheet for a country is available. CO₂ emissions may also be calculated at the more detailed (i.e. sectoral) level. Non-Annex I Parties are encouraged to estimate and report CO₂ emissions using both the sectoral and reference approaches, and explain any large differences between the two approaches.

The reference approach provides a potentially useful way of cross-checking emission estimates of CO₂ with those calculated using the sectoral approach and thus helps to identify inconsistencies or mistakes. The sectoral approach provides greater detail on the combustion activities responsible for emissions.

4.1.1.1 ESTIMATION STEPS

The estimation process for estimating CO₂ emissions from fuel combustion using the Tier 1 reference or the Tier 2 or 3 sectoral approaches can be divided into the following steps:

1. COLLECTION OF FUEL CONSUMPTION DATA

The first step of the IPCC *reference approach* is to estimate apparent consumption of fuels within the country. This step requires a balance of primary fuels produced, plus imports, minus exports, minus international bunkers and the net changes in stocks. Carbon is brought into the country from energy production and imports (adjusted for stock changes) and removed from the country through exports and international bunkers. In order to avoid double counting, it is important to distinguish between primary fuels, which are fuels found in nature, such as coal, crude oil and natural gas, and secondary fuels or fuel products,

such as gasoline and lubricants, which are derived from primary fuels. Note that “apparent consumption” of secondary fuels can result in negative numbers when a net export or stock of a particular fuel type increases for the country. “Apparent consumption” of secondary fuels should be added to the “apparent consumption” of primary fuels. The production of secondary fuels through refining processes should be ignored in the calculations, because the carbon in these fuels will already have been included in the calculation of the primary fuels from which they were derived.

Similarly, the first step for the *sectoral approach* is to collect actual consumption statistics by fuel type and economic sector (e.g. public electricity and heat production, petroleum refining, manufacture of solid fuels and other energy industries).

The first step for a Tier 2 or 3 method is to collect actual fuel consumption statistics by fuel type, economic sector and combustion technology type. Tier 3 methods use activity data (e.g. kilometres travelled) as a proxy to estimate fuel consumption or CO₂ emissions directly using emission factors. Tier 3 methods are generally used for estimating only non-CO₂ emissions, because using actual fuel data is more accurate in most cases for estimating CO₂ emissions.

2. CONVERSION OF FUEL DATA TO A COMMON ENERGY UNIT

In the Organisation for Economic Co-operation and Development/International Energy Agency, Energy Statistics and other national energy data, compilations of production and consumption of solid and liquid fuels are generally specified in tonnes, and gaseous fuels in cubic metres. For consistency purposes, original units should be converted into energy units using NCVs (i.e. heating values). Where available, different calorific values for production, imports and exports should be used. For transparency purposes, the calorific values used should be reported. Some countries may report GC Vs, depending on their national statistics systems.

¹¹ Autoproduction refers to electricity, heat or steam produced by an industrial facility for its own consumption or sale to other consumers or to the electricity grid. Autoproduction is sometimes also called autogeneration, self-generation or self-production.

3. SELECTION OF CARBON CONTENT FACTORS FOR EACH FOSSIL FUEL/PRODUCT TYPE AND ESTIMATION OF THE TOTAL CARBON CONTENT OF FUELS CONSUMED

There is considerable variation in the energy and carbon content by weight and volume of fuels. However, expressing carbon content on a per-unit-of-energy basis reduces this variation because of the close link between the carbon content and energy value of the fuel. Carbon content factors may vary considerably both between and within primary fuel types.

4. SUBTRACTION OF THE AMOUNT OF CARBON STORED IN PRODUCTS FOR LONG PERIODS OF TIME (E.G. NON-ENERGY USES).

The reference approach requires information on the consumption of fuels used for non-energy purposes where carbon may be stored (i.e. not oxidized and emitted to the atmosphere). The reference approach uses a simple assumption: once carbon is brought into a national economy in the form of a fuel, it is either saved in some way (e.g. in increases of fuel stocks, stored in products, or left unoxidized in ash), or it is emitted into the atmosphere.

Some of the fuels supplied to an economy can be used for non-energy purposes or as raw materials (i.e. feedstocks) for the manufacture of products. A wide variety of products are produced from oil refineries, including asphalt and bitumen for road construction, naphthas, lubricants, plastics and fertilizers. Natural gas is used for ammonia production. Liquified petroleum gas (LPG) is used to produce solvents and synthetic rubber. By-products of the coking process, such as oils and tars, are used in the chemical industry. In some of these cases, the carbon in these fuels is oxidized to CO₂ within the non-energy process (e.g. carbon from natural gas used in ammonia production). In other cases, the carbon is indefinitely stored (i.e. sequestered), although the carbon in some products may be oxidized as the product ages or is disposed of. The amounts stored for long periods are called stored carbon and should be deducted from the carbon emissions calculation.

Several approaches for estimating the amount of carbon stored in products are contained in the Revised 1996 IPCC Guidelines. The IPCC recommends that, whenever possible, Parties should use country-specific data and assumptions instead of relying on IPCC default factors.

The basic equation for estimating the amount of carbon stored in products is given below:

Equation 3 – Total Carbon Stored¹²

Total Carbon Stored (Gg C) =

Non-Energy Use (10³ t)

x Conversion Factor (TJ/10³ t)

x Emission Factor (t C/TJ)

x Fraction Carbon Stored

x 10⁻³

The IPCC default storage factors for fossil fuels that have been sold for non-energy or feedstock use are given below. It is important to note that these default factors are based on expert opinion of the likely global average. National practices may differ greatly. Countries should focus their efforts on collecting accurate non-energy use fuel consumption data and, where possible, investigate the use and fate of the carbon in the fuels consumed for non-energy purposes.

5. MULTIPLICATION BY AN OXIDATION FACTOR TO ACCOUNT FOR THE SMALL AMOUNT OF UNOXIDIZED CARBON THAT IS LEFT IN ASH OR SOOT.

Parties should use oxidation factors that match their national circumstances. Several countries have commented that the amount of carbon remaining unoxidized can vary greatly from the general assumption of 1 per cent across all oil-related fuels. For example, it has been noted that the amount of unburned carbon varies depending on several factors, including type of fuel consumed, type of combustion technology, age of the equipment, and operation and maintenance practices.

6. CONVERSION OF CARBON TO FULL MOLECULAR WEIGHT OF CO₂ AND SUMMATION ACROSS ALL FUELS.

To express the results as CO₂, the quantity of carbon oxidized should be multiplied by the molecular weight ratio of CO₂ to C (i.e. 44/12).

In addition to the steps described above, emissions of CO₂ from international bunker fuels and biomass used as a fuel should be handled as follows:

- *Bunker fuels:* CO₂ emissions arising from fuels used in ships or aircraft for international transport should not be included in the national total. The quantities of fuels delivered to and consumed by international bunkers should be subtracted from the fuel supply to the country. The calculated bunker fuel emissions should be mentioned as a memo item.
- *Biomass fuels:* Biomass fuels are included in the national energy and emissions accounts for completeness only. The resultant CO₂ emissions should not be included in national CO₂ emissions from fuel combustion. The release of carbon due to biomass used as energy should be accounted in the LULUCF sector. Non-CO₂ emissions from biomass combustion, however, should be reported under the Energy sector.

Because of the difficulties many Parties have in allocating marine and aviation transport emissions between international and domestic categories, the IPCC has provided a detailed decision tree and guidance for each in the IPCC good practice guidance. The CGE GHG Inventory Handbook, Energy sector – Fuel Combustion document contains decision trees and a table describing how to distinguish individual travel segments between international and domestic, starting on page 15. It is understood that many Parties will have difficulty strictly applying this guidance due to lack of detailed data.

Non-CO₂ emissions. The methods (i.e. tiers) for estimating non-CO₂ emissions require different levels of detail for activities and technology.

Tier 1. Emissions from all sources of combustion are estimated by multiplying the quantity of fuel consumed by an average emission factor. Tier 1 methods do not require detailed activity data.

Tiers 2/3. Emissions are estimated by multiplying the quantity of fuel consumed by detailed fuel type and technology-specific emission factors.

Tier 1 methods rely on widely available fuel supply data that assume an average combustion technology is used. The difference between Tiers 2 and 3 is mainly an increase in the degree of detail required by the method. In

general, Tier 2 methods use fuel consumption data that are disaggregated according to technology types and that are sufficiently homogenous to permit the use of representative emission factors. Tier 3 methods generally estimate emissions according to activity types (km travelled or tonne-km carried) and specific fuel efficiency, fuel rates, emission factor or factors expressed directly in terms of a unit of activity.

All tier methods rely on the same fundamental equation:

Equation 4 – Total Carbon Stored¹³

$$\text{Emissions} = \sum (\text{Emission Factor}_{abc} \times \text{Fuel Consumption}_{abc})$$

Where:

- a = fuel type
- b = sector activity
- c = technology type

Alternatively, countries may use national emission models or continuous emission measurement of CH₄ and N₂O, which is consistent with good practice. However, in most cases, continuous emission measurements are not justified because of the high cost of performing the measurements.

It is good practice to use the most disaggregated technology-specific and country-specific emission factors available, particularly those derived from direct measurements for stationary combustion sources. Using a Tier 2 approach, there are three possible types of emission factors:

- National emission factors;
- Regional emission factors;
- IPCC default emission factors, provided that a careful review of the applicability of these factors to the country's conditions has been made. IPCC default factors may be used when no other information is available.

¹² Materials for the hands-on training workshops of the CGE Energy sector – Fuel Combustion, page 12. Available at <http://unfccc.int/resource/cd_roms/na1/ghg_inventories/index.htm>.
¹³ Materials for the hands-on training workshops of the CGE Energy sector – Fuel Combustion, page 20.

4.1.1.2 STATIONARY COMBUSTION

Default emission factors for CH₄, N₂O, NO_x, CO and NMVOCs by major technology and fuel types are presented in the Revised 1996 IPCC Guidelines, Reference Manual – Volume 3. Data are also presented on typical sulphur contents of fossil and biomass fuels. Alternative control technologies, with representative percentage reductions are also shown. These data show the range and variation of sources and emission rates, as well as the impact of the control technologies.

Of particular importance for many countries are CH₄ emissions from various types of open burning and biomass combustion because of the highly inefficient nature of the combustion process in many cases. In particular, charcoal production is likely to produce methane emissions at a rate that is several orders of magnitude greater than other combustion processes.

4.1.1.3 MOBILE COMBUSTION

Emissions of GHGs from mobile sources can be estimated by major transport activity (road, air, rail and ships). However, as road transportation accounts for the majority of mobile-source fuel consumption, followed by air transport, greater priority has been attached to the development of emission models and inventories for road vehicles and aircraft. The diversity of mobile sources and the range of characteristics that affect emission factors are demonstrated and can be seen in the tables included in the Revised 1996 IPCC Guidelines.

Of particular importance for many countries are N₂O emissions from road transportation, which are considerably affected by the type of emission control technologies in use. Some catalyst-type control technologies can increase the rate of N₂O emissions relative to an uncontrolled vehicle. Non-Annex I Parties should focus their efforts on collecting data on the number of vehicles with catalytic emission-control devices that operate in their country. The type of catalytic control equipment can often be approximated by the age and make of the vehicle if it is not known. As shown in the table on page 26 of the Materials for the hands-on training workshops of the CGE, GHG Inventory: Energy Sector – Fuel Combustion document, N₂O emission rates can vary dramatically (i.e. by an order of magnitude) due to the effect of different vehicle control technologies.

4.1.2 FUGITIVES

In the Energy sector, fugitive emissions from fuels can be divided into source categories related to solid fuels (primarily coal) and oil and natural gas systems. The dominant GHG emitted from all of these source categories is CH₄, although smaller amounts of CO₂ are also emitted from some sources.

For solid fuels, venting and disposal of coal-bed methane is the primary source of fugitive emissions. Most of these emissions occur at the mine with some residual emissions occurring from post-mining handling/processing activities.

4.1.2.1 COAL MINING

There are two types of coal mines: surface and underground. The specific emission rates from coal mining depend primarily on the relative contribution of surface and underground mining to a country's total coal production. CH₄ emissions from surface mines are usually an order of magnitude lower than from those underground mines. For underground mines, the amount of emissions tends to increase with the depth of the mine. For both types of mines, the potential for emissions is determined by the gas content of the coal. Some gas may remain in the coal until combustion; however, most (60% – 75%) is released during the mining activity. Emissions from coal handling are related to the type of mine from which the coal was produced, and are primarily associated with crushing operations.

Emissions from coal mines may continue after the mines have stopped producing coal (i.e. abandoned mines). Typically, the amount of emissions declines rapidly once deep mine coal production stops; however, in some cases, CH₄ emissions from the surrounding strata may be substantial and continue for years afterwards. Coal waste or reject piles are only a minor source of CH₄ emissions.

There are practicable options for controlling emissions from coal mining and handling. These may include the use of degasification wells with either conservation or flaring of the produced gas or the use of catalytic combustors on the outlet of ventilation systems for underground mines.

Useful monitoring and activity data for developing emissions estimates including the CH₄ content of exhausted ventilation air, coal production, imports and exports by type of coal, and information on the depth of each mine, may be available.

4.1.2.2 OIL AND NATURAL GAS

Oil and natural gas systems are potentially very complex and diverse. Specific fugitive emission rates may vary greatly according to:

- 1) The type of oil or gas being produced, processed or handled (e.g. conventional crude oil, heavy oil, crude bitumen, dry gas, sour gas, associated gas);
- 2) The stage of the system;
- 3) The type and age of facility;
- 4) Operating, maintenance and design practices;
- 5) Local regulatory requirements and enforcement.

The primary types of fugitive emission sources at oil and gas facilities are fugitive equipment leaks, process venting and flaring, evaporation losses (e.g. from product storage and handling, particularly where flashing losses occur), and accidental releases or equipment failures.

Accidental releases are difficult to predict, but can be a substantial contributor where major well blowouts or pipeline ruptures have occurred. Accidental releases or equipment failures can include:

- Well blowouts;
- Pipeline breaks;
- Tanker accidents;
- Tank explosions;
- Gas migration to the surface around the outside of wells;
- Surface casing vent blows: a surface casing vent blow may be caused by a leak from the production casing into the surface casing or by fluid migration up into the surface casing from below;
- Leakage from abandoned wells: emissions from abandoned wells result from unsuccessful abandonment procedures.

Gas migration to the surface may be caused by a leak in the production string at some point below the surface casing or by the migration of material from one or more of the hydrocarbon-bearing zones that were penetrated (e.g. a coal seam).

Storage losses are primarily a source of non-methane hydrocarbons, but can contribute substantial amounts of CH₄ emissions where flashing or boiling losses occur. Such losses occur when a hydrocarbon liquid is sent from

a pressure vessel where it has been in contact with a gas phase, which is the case at most production facilities. Thereafter, the hydrocarbon liquids contain little CH₄.

In general, the amount of fugitive emissions from oil and gas activities tends to correlate poorly with production levels or system throughputs. It is more closely related to the amount, type, and age of process infrastructure (i.e. equipment); the characteristics of the hydrocarbons being produced, processed or handled; and the industry design, operating and maintenance practices. Emissions from venting and flaring depend on:

- The amount of process activity;
- Operating practices;
- On-site utilization opportunities;
- Economic access to markets;
- The local regulatory environment.

With the exception of petroleum refineries, integrated oil sands mining and upgrading operations, oil and gas systems tend to be characterized more by multiple smaller facilities and installations rather than a few large ones. Moreover, while reasonable information is typically available for the larger facilities, it is usually the smaller facilities that contribute most of the fugitive emissions, and information on these smaller facilities is much less likely to be available.

Generally, the relative amount of fugitive emissions depends on many factors, but emissions tend to increase as you go upstream through a system, and decrease with the concentration of hydrogen sulphide (H₂S) in the produced oil and gas. Typically, raw natural gas and crude oil both contain a mixture of hydrocarbons and various impurities including H₂O, N₂, argon (Ar), hydrogen sulphide (H₂S) and CO₂. If natural gas contains more than 10 ppmv (parts per million by volume) of H₂S it is generally referred to as sour gas, and otherwise is called sweet gas. The impurities are removed by processing, treating or refining, as appropriate. The raw CO₂ that is removed from hydrocarbons is normally vented into the atmosphere and is a source of fugitive emissions. This fact has been overlooked by some countries. Contributions of raw CO₂ emissions occur primarily at sour gas processing plants. Offshore production and production from foothills or mountainous regions tends to be sour or have high CO₂ concentrations. The concentration of H₂S tends to increase with the depth of the well.

Two major issues concerning the reported fugitive emissions from oil and gas systems are:

- 1) The generally poor quality and completeness of available venting and flaring data;
- 2) The fact that much of the infrastructure contributing to equipment leaks is at minor facilities for which statistics are either unavailable or incomplete (e.g. well-site facilities and field facilities).

FUGITIVE EQUIPMENT LEAKS

Unintentional leaks from equipment components include, but are not limited to: valves, flanges and other connections, pumps, compressors, pressure relief devices, process drains, open-ended valves, pump and compressor seal system degassing vents, accumulator vessel vents, agitator seals, and access door seals. Fugitive sources tend to be continuous emitters and have low to moderate emission rates. Essentially, all equipment components leak to some extent; however, only a few per cent of the potential sources at a site leak a sufficient amount to require repair or replacement. If the number of leakers is less than 2% of the total number of potential sources, the facility is normally considered to be well maintained and fugitive equipment leaks, properly controlled.

Fugitive leaks from equipment are a large, if not the largest, source of methane and non-methane hydrocarbon emissions at oil and gas facilities. Some of the common trends identified in the available leak data are as follows:

- Components on fuel gas systems tend to leak more than components on process gas systems. This likely reflects a lower level of care and attention and use of lower quality components in fuel gas applications;
- The potential for leaks tends to decrease as the value or toxic nature of the process fluid increases, and where gas has been odorized. Thus, leak frequencies for equipment components in sour service are much lower than for components in sweet service. At sour gas plants, often only a small portion of the plant is actually in sour service;
- The stem packing on control valves tends to leak more than on block valves;
- Hydra-mechanical governors¹⁴ on compressor engines tend to be the most leak-prone component in control valve service;
- Components tend to have greater average emissions when subjected to frequent thermal cycling, vibrations or cryogenic service.

VENTING AND FLARING

Flare and vent systems exist in essentially all segments of the oil and gas industry and are used for two basic types of waste gas disposal: intermittent and continuous.

Intermittent applications may include:

- The disposal of waste volumes from emergency pressure relief episodes;
- Operator initiated or instrumented depressurization events (e.g. depressurization of process equipment for inspection or maintenance, or depressurization of piping for tie-ins);
- Plant or system upsets;
- Well servicing and testing;
- Pigging events;
- Routine blowdown of instruments, drip pots and scrubbers.

Continuous applications may include:

- Disposal of associated gas and/or tank vapours at oil production facilities where gas conservation is uneconomical or until such economics can be evaluated;
- Casing gas at heavy oil wells, process waste or by-product streams that either have little or no value or are uneconomical to recover (e.g. vent gas from glycol dehydrators, acid gas from gas sweetening units, and sometimes stabilizer overheads);
- Venting gas from gas-operated devices where natural gas is used as the supply medium (e.g. instrument control loops, chemical injection pumps, samplers).

Typically, waste gas volumes are flared if they pose an odour, health or safety concern; in all other cases, they are vented.

There are often inconsistencies in what individual companies include in their reported vented and flared volumes. In some cases, this is due to differences in reporting requirements between jurisdictions. In other cases, it is due to a lack of specificity in the current requirements, inconsistent industry practice and only superficial auditing of the results.

All measured quantities are likely to be fully accounted. However, flow meters are normally only installed on larger continuous vent or flare systems, if at all. Where

flow meters are installed on intermittent flares, they are usually sized, due to limitations in their operating range, to measure only peak flow rates. As a result, there is the potential for substantial leakage into vent and flare systems to persist undetected.

Where there is no measurement data the volumes must be estimated using expert judgment. The main problems with this approach are the lack of detailed estimation guidelines, the lack of any formal tracking of the activity data needed to make many of these judgments (e.g. frequency and details of equipment or piping blowdown events, frequency of compressor engine starts), and differences regarding which sources individual operators take into account.

Historically, there has been a problem with some vented volumes being reported as flared. The actual split has a substantial impact on the total CO₂ equivalent emissions from these activities because unburned CH₄ contributes approximately 7.6 times more radiative forcing on a 100 year time horizon than fully combusted CH₄ (i.e. the oxidized carbon from 1 tonne of CH₄ produces 2.75 tonnes of CO₂ in the atmosphere, but when weighted by their global warming potential (GWP) values, the CO₂ has 7.6 times less cumulative radiative forcing impact than the methane).

ACID GAS

Acid gas is a by-product of the sweetening process at sour gas processing plants and refineries, and may contain large amounts of raw CO₂ extracted from process gas (typically, from 20 to 95 mol per cent CO₂). The rest of the acid gas tends to be mostly H₂S. The amount of acid gas production is usually metered and the CO₂ content, although not normally tracked by regulatory agencies, is known by the facility operators. Regardless of whether the acid gas is processed by a sulphur recovery unit, flared or vented, the raw CO₂ passes through the system unchanged and is ultimately released into the atmosphere.

STORAGE LOSSES

Storage tanks are typically only a source of CH₄ emissions where boiling or flashing losses occur (i.e. the product contains some natural gas in solution). This occurs at production and processing facilities where a hydrocarbon liquid flows directly from a pressure vessel, where it has been in contact with natural gas (e.g. an inlet separator or

oil treater), to an atmospheric storage tank. Once placed in storage tanks, the solution gas quickly volatilizes, leaving a weathered, more stable product that is essentially free of CH₄. Pipeline and marine terminals and refineries normally receive weathered products.

Other less recognized and often unaccounted for contributors to atmospheric emissions of CH₄ from storage tanks may include the following:

- Leakage of process gas or volatile hydrocarbon liquids past a closed drain or blowdown valves into the product header leading to the tanks;
- Inefficient separation of gas and liquid phases upstream of the tanks allowing some gas carry through (by entrainment) to the tanks. This usually occurs where inlet liquid production (e.g. produced water) has increased substantially over time resulting in a facility's inlet separators being undersized for current conditions;
- Piping changes resulting in the unintentional placement of high vapour pressure product in tanks not equipped with appropriate vapour controls;
- Displacement of large volumes of gas to storage tanks during pigging operations;
- Malfunctioning or improperly set blanket gas regulators and vapour control valves can result in excessive blanket gas consumption and, consequently, increased flows to the end control device (e.g. vent, flare or vapour recovery compressor). The blanket gas is both a carrier of product vapours and a potential pollutant itself (i.e. natural gas is usually used as the blanket medium for blanketed tanks at gas processing plants).

4.1.2.3 OTHER FUGITIVE SOURCES

Other less common sources of fugitive emissions from fuels include peat production and geothermal energy-related emissions. Checks should be performed to determine if these additional sources occur, and if so, whether their emissions have been reported.

¹⁴ The engine governor controls engine speed, and in some generator applications, generator load. Hydra-mechanical governors sense engine speed mechanically, and use the engine's oil pressure to hydraulically move the actuator controlling fuel flow to the cylinders.

All fugitive source categories tend to emit substantial quantities of CH₄ and/or CO₂, but are only minor contributors of N₂O, if at all. Fugitive emissions of N₂O can result from flaring activities. Some emission factors are available in the literature for estimating N₂O emissions from flaring; these are generally comparable to or less than the values published for small heaters and boilers.

4.2 INDUSTRIAL PROCESSES

The chemical reactions involved in the source categories listed below are described in the specified sections of the Revised 1996 IPCC Guidelines, Volume 3. The respective

chemical equations generally indicate energy/heat requirement initiation and/or sustaining the chemical reaction kinetically and thermodynamically. The emissions associated with the energy input are not regarded as Industrial Process sector emissions and therefore are not included in the emission factor estimation. They are accounted for under source category 1A2 – Manufacturing industries and construction in the Energy sector. To avoid double counting, it is recommended that the non-energy use (NEU) related emissions reported in the Industrial Processes sector be calculated based on the use of reducing agents, particularly for the source categories in metal production:

Source (IPCC Guidelines, Volume 3)	Description
Cement Production (2.3.1)	The most important source of non-energy industrial process emissions. CO ₂ is produced during the production of clinker and intermediate product from which cement is made, as clinker is produced from raw materials at high temperatures inside a kiln. Calcium carbonate from a calcium-rich material forms lime and CO ₂ during the calcination process.
Lime production (2.4.1)	CO ₂ emissions are released during the production of calcined limestone as it is formed by heating at high temperatures in a rotary kiln.
Soda ash production and use (2.6.1)	Soda ash, which is used as a raw material in many industries, emits CO ₂ during both its production and use. Emissions from the production of soda ash vary greatly according to the manufacturing method, as four different processes are commercially used. CO ₂ is emitted during the production of soda ash because the reaction produces more CO ₂ than is stoichiometrically required. CO ₂ emissions are also released during the use of soda ash for processes such as the manufacture of glass, chemicals, soaps, detergents and flue gas desulphurization. A 1:1 ratio of soda ash use to CO ₂ emissions is assumed by the United States Environmental Protection Agency.
Ammonia production (2.8.1 and 2.8.2)	Ammonia is typically produced by catalytic steam reforming of natural gas (CH ₄) or other fossil fuels, which results in the production of CO ₂ .
Silicon carbide (2.11.1)	CO ₂ is released as a by-product of the reaction between quartz and carbon during the production of silicon carbide. More carbon than is indicated in the stoichiometric reaction is actually required for silicon carbide production, with the excess carbon being oxidized during the process. Petrol coke, which is often used as a carbon source, may contain volatile compounds which form CH ₄ that may escape into the atmosphere. Some carbon (about 35%) is sequestered in the product.
Calcium carbide (2.11.2)	Calcium carbide is produced through a two-step process which includes heating calcium carbonate and then reducing calcium oxide (CaO) with carbon, both of which lead to CO ₂ emissions. Furthermore, the use of calcium carbonate (typically for acetylene production) releases CO ₂ emissions. While some carbon is sequestered in the product, it may be ignored as this is for a short time only.
Iron and steel (2.13.3.2)	Iron production requires raw ore to be heated to form molten pig ore through heating in the presence of carbon and oxygen. Steel may be produced in one of four types of furnaces, with different carbon contents associated with each.
Ferroalloys (2.13.5.1)	Ferroalloys (alloys of iron and one or more metals) are produced by smelting together raw ore, coke and slagging materials. The smelting process results in significant CO emissions, which are assumed to be converted to CO ₂ within days afterwards.
Aluminium (2.13.5.1)	Aluminium is made in a two-step process. Bauxite ore is ground, purified and calcined to produce alumina, which is then electrically reduced to aluminium by smelting. The main gaseous reaction product of the process is CO ₂ .

The general approach to estimation of Industrial Processes emissions is the application of the equation below:

Equation 5 – Industrial Processes Emissions Estimation¹⁵

$$\text{TOTAL}_{ij} = \text{Activity Data} \times \text{Emission Factor}$$

Where:

TOTAL_{ij} = process emission (tonne) of gas i from industrial sector j
Activity Data = amount of activity or production of process material (AD) in industrial sector j (tonne/yr)
Emission Factor = emission factor associated with gas i per unit of activity in industrial sector j (tonne/tonne)

4.2.1 CHOICE OF METHODS

For certain industrial processes, more than one estimation methodology is presented. These are:

- 1) Simplified approach, referred to as Tier 1;
- 2) More detailed methodology, referred to as Tier 2.

Several options are also provided for certain industrial processes under Tier 1, as Tier 1a, 1b and 1c, based on data availability and suitability of methods. In such cases, the order of preference for Tier 1 methods is 1a>1b>1c.

Typical selected tiers by sub-source categories in the Revised 1996 IPCC Guidelines are summarized as follows:

- a) 2B1 – Ammonia production (CO_2)
Tier 1a – AD as natural gas consumption (m^3) and EF (kgC/m^3)
Tier 1b – AD as ammonia production (tonnes) and EF (tonne CO_2 /tonne NH_3);
- b) 2C5 – Calcium carbide production (CO_2)
Tier 1a – Consumption of petroleum coke (tonne) and EF (tonne C/tonne coke type)
Tier 1b – Production of carbide;

- c) 2C – Metal production (iron and steel, Al, ferro-alloys)
Tier 1a – Consumption of reducing agent (tonne) and EF (tonne C/tonne reducing agent)
Tier 1b – Production of the metal (tonnes) and EF (tonne CO_2 /tonne metal);
- d) PFCs from aluminium production
Tier 1a – Direct plant emissions data
Tier 1b – Estimation based on plant measurements and empirical estimation
Tier 1c – Based on aluminium production (tonnes) and default emission factor ($\text{kg}/\text{tonne Al}$);
- e) 2F – HCFC manufacture (HFC-23 release)
Tier 1 – AD total production (tonnes) and Default EF (% of total production)
Tier 2 – Direct emissions from plant-specific measurements using standard methods;
- f) 2E – Consumption of Ozone Depleting Substances (ODS) substitutes (HFCs, PFCs and SF_6)
Tier 1a and Tier 1b – Potential emissions
Tier 2 – Actual emissions.

4.2.2 CHOICE OF ACTIVITY DATA

Activity data sources include:

- Plant-level measurements or direct emissions reports with documented methodologies;
- Where direct measurements are not available, estimations are based on calculation with plant-specific data;
- International data set (United Nations data sets and industry associations);
- National databases, where available from appropriate government ministries (e.g. statistics services, environmental protection agencies);
- Standard production statistics from national statistical publications.

¹⁵ CGE GHG Inventory Handbook (Non-Annex I), Industrial Processes Sector, page 3.

4.2.3 CHOICE OF EMISSION FACTORS

The various types of emission factors can be classified as follows:

- Process-reaction-based EFs (stoichiometric ratios);
- Production-based EFs;
- Technology-specific EFs;
- Reported country/region-specific plant-level measurements.

4.3 AGRICULTURE¹⁶

The Agriculture sector includes all anthropogenic emissions associated with agriculture activities except for fuel combustion and sewage emissions, which are covered in Energy and Waste sectors, respectively.

The following categories are included in this sector:

- Enteric fermentation;
- Manure management;
- Rice cultivation;
- Agricultural soils;
- Prescribed burning of savannahs;
- Field burning of agricultural residues;
- Other.

Details of each category are contained in the following:

Enteric fermentation (4A): CH₄ production from herbivores as a by-product of enteric fermentation, a digestive process by which carbohydrates are broken down by micro-organisms into simple molecules for absorption into the bloodstream. Both ruminant (e.g. cattle, sheep) and non ruminant animals (e.g. pigs, horses) produce CH₄, although ruminants are the largest source (per unit of feed intake). Information to be reported under this category is organized by animal groups: Cattle (Dairy and Non-dairy), Buffalo, Sheep, Goats, Camels and Llamas, Horses, Mules and Asses, Swine, Poultry, and Other.

Manure management (4B): CH₄ and N₂O are produced from the decomposition of manure under low oxygen or anaerobic conditions. These conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons and other types of manure

management systems. This category includes the same subcategories as 4A, plus the following Anaerobic, Liquid systems, and Solid storage and Drylot.

Rice cultivation (4C): The anaerobic decomposition of organic material in flooded rice fields produces CH₄, which escapes into the atmosphere by ebullition (bubbling up) through the water column, diffusion across the water-air interface and transport through the rice plants. It is suggested that these CH₄ emissions be based on lowland rice ecosystems without organic amendments relating to water regime, where lowland refers to fields flooded for a significant period of time. Correction factors for soils with organic amendments should be applied as necessary. Any N₂O emissions from the use of nitrogen-based fertilizers in rice cultivation should be reported under category 4D Agricultural soils. This category encompasses the following subcategories: Irrigated (both Continuously flooded and Intermittently flooded), Rain fed (Flood-prone and Drought-prone), Deepwater and Other.

Agricultural soils (4D): Emissions and removals of CH₄ and N₂O from agricultural soil/land and NMVOCs from crops. These are influenced by irrigation practices, climatic variables, soil temperature and humidity. CO₂ emissions from, and removals by, agricultural soils are reported under the LULUCF sector. Any N₂O emissions from the use of nitrogen-based fertilizers in rice cultivation should be reported here. N₂O emissions may be related to the use of both organic and inorganic fertilizers, biological nitrogen fixation, and return of crop residues to the field or to animal production. Non-CO₂ GHG emissions associated with the use of compost and human waste as fertilizers should also be recorded in this category. Emissions of N₂O from sewage are to be reported under Waste (6B) and N₂O emissions from animal waste management systems other than grazing, under manure management (4B). Emissions of N₂O from manure used for fuel are reported under Energy (1A).

Prescribed burning of savannas (4E): Emissions of CH₄, CO, N₂O and NO_x from the burning of savannas (tropical and subtropical formations with continuous grass cover, occasionally interrupted by trees and shrubs). Savannas are burned to control the growth of vegetation, remove pests and weeds, promote the nutrient cycle and encourage the growth of new grass for animal grazing. CO₂ from prescribed savanna burning is noted for information purposes, but is not included in the inventory total, since it is assumed that an equivalent amount of CO₂ is removed by re-growing vegetation in the following year.

Field burning of agricultural residues (4F): Emissions of non-CO₂ GHGs from burning (in the field) of crop residue and other agricultural wastes on site. These include: woody crop residues (e.g. coconut shells, jute sticks, etc.); cereal residues (e.g. rice and wheat straw, maize stalks, etc.); and green crop residues (e.g. groundnut straw, soybean tops, etc.). The burning of agricultural waste for energy is excluded here, but included under fuel combustion activities in Section 1A. CO₂ from vegetal or biomass burning is noted for information purposes, but is not included in the inventory total, since it is assumed that a roughly equivalent amount of CO₂ is removed by re-growth of the next crop. The following sub modules are included in this category: Cereals, Pulses, Tubers and roots, Sugar cane and Other.

Other (4G): This includes other sources in the Agriculture sector not covered by any of the other categories that may be relevant in certain countries.

4.3.1 CHOICE OF METHOD

Enteric fermentation (4A): Tier 1 and Tier 2 methods are provided for this category. Tier 1 consists in determining the number of animals in each group, and multiplying the figure by an emission factor. The Tier 2 method (for cattle only, although a Tier 2 method for sheep was also provided by the IPCC good practice guidance) uses an enhanced characterization of livestock population, which results in an estimation of the average annual feed intake for every group of animals, which is in turn used for calculating the emission factor.

Manure management (4B): For CH₄ emissions, the IPCC Guidelines provide both a Tier 1 and a Tier 2 method. Both tiers use an emission factor that is combined with the number of animals in each category to obtain the amount of emissions. Tier 1 requires livestock population data by climate region and uses default emission factors, whereas Tier 2 estimates the emission factor from manure characteristics (volatile solids excreted, maximum CH₄ production capacity, and methane conversion factor). Tier 2 also requires detailed information on animal characteristics and the manner in which the manure is handled.

For N₂O only a Tier-1 method is provided, which involves five steps:

- 1) Livestock characterization;
- 2) Determination of total nitrogen (N) excretion rate per head for each livestock category;
- 3) Determination of the fraction of N excretion that is managed in each manure management system;
- 4) Determination of an emission factor for each manure management system;
- 5) Calculation of emissions by multiplying activity data by emission factors.

Rice cultivation (4C): The IPCC Guidelines provide only one method for CH₄ from rice production. It uses annual harvested data (broken down by rice ecosystem or water management type) and use of organic amendments and soil types as activity data. Emission factor is calculated by first estimating a basic factor for continuously flooded fields without organic amendments, which is then scaled to account for several production characteristics (i.e. cropping practices, use of multiple crops, ecosystem type, water management regime, addition of organic amendments, and soil type).

Agricultural soils (4D): The IPCC Guidelines provide one method for direct, and one for indirect, N₂O emissions from agricultural soils. No methods are provided for CH₄ emissions or removals, or for N₂O removals by agricultural soils.

For direct N₂O emissions due to N inputs to soils (synthetic fertilizers, animal manure, use of N-fixing crops, incorporation of crop residues into soil and N mineralization in organic soils), the IPCC Guidelines provide a Tier 1 method (later classified into Tier 1a and Tier 1b by the IPCC good practice guidance). Two emission factors are required for this method, one to account for emissions from N inputs, and another to account for N mineralized from organic soil cultivation. Regarding activity data, several parameters need to be estimated: annual use of synthetic fertilizers, annual use of manure, amount of N fixed by crops, amount of crop residues returned to soil, and area of organic soils cultivated annually.

¹⁶ Source: CGE GHG Inventory Handbook (Non-Annex I), Agriculture Sector, page 10.

For indirect N₂O emissions, the IPCC Guidelines describe how to estimate emissions from three sources:

- a) Volatilization of applied synthetic fertilizer and animal manure N, and its subsequent atmospheric deposition as NO_x and NH₄;
- b) Leaching and runoff of applied fertilizer and manure N;
- c) Discharge of human sewage N into rivers or estuaries.

A Tier 1 method (later classified into Tier 1a and Tier 1b by the IPCC good practice guidance) is provided for each of these sources.

Prescribed burning of savannas (4E): A simple method is provided in the IPCC Guidelines, based on estimation of activity data (the area burned annually and biomass burned) and emission ratios for CH₄, CO, N₂O and NO_x.

Field burning of agricultural residues (4F): The IPCC method for non-CO₂ gases from burning of agricultural residues is similar to that for burning of savannas, consisting of the multiplication of activity data by emission ratios.

Other (4G): Varies depending on source.

4.3.2 CHOICE OF ACTIVITY DATA

In many cases, the main barrier to elaborate an accurate inventory is the availability of activity data. Many Parties do not have institutional arrangements to systematically collect and regularly publish the activity data that the IPCC Guidelines ask for. If this is the case, it may be necessary or the Party to improve its institutional framework, given that the capacity FOR data collection and reporting is important not only for the inventory elaboration, but also for the national decision-making process in all the sectors of the national life.

However, if there is no time and/or the Party lacks in financial resources to overcome this deficiency in its institutional framework, the activity data (such as animal populations, crop surface/yield, animal population, national consumption of nitrogen fertilizers, among others), might be identified within the United Nations Food and Agriculture Organization database¹⁷ which may provide alternate activity data, allowing the Party to build up its inventory.

When dealing with partitioning parameters (such as amount of manure produced per animal species, N content of manure, manure by animal waste management system, crop/residue ratio, carbon content in crop residues, fraction of surface burned, among others), there are two ways to produce the values:

- The use of the IPCC default values (included in the guidelines and the IPCC Emission Factor Database [EFDB]), or
- National expertise.

The availability of activity data is the primary driving factor that conditions the accuracy and reliability of the inventory.

4.3.3 CHOICE OF EMISSION FACTOR

For Tier 1, default emission factors are used while Tier 2 emission factors are derived from available data.

4.4 LAND USE, LAND-USE CHANGE AND FORESTRY

The IPCC Guidelines provide approaches, methodologies and technical guidance for preparing a GHG inventory for the LULUCF sector. The fundamental basis for the inventory methodology rests upon two linked assumptions:

- i. The flux of CO₂ to/from the atmosphere is equal to changes in carbon stocks in the existing biomass and soils,
- ii. Changes in carbon stocks can be estimated by first establishing the rates of change in land use and the practice used to bring about the change (e.g. burning, clear-cutting, selective cutting, change in silviculture or management practice, etc.).

This requires the estimation of the land use in the inventory year, conversion of forest or grasslands, and the stocks of carbon in the land-use categories (those that are subjected to change and those that are not).

4.4.1 CHOICE OF METHOD

The IPCC Guidelines provide a default approach, methodology and default data for a GHG inventory for the LULUCF sector. The default approach involves estimating the GHG inventory using four categories, namely:

- *Changes in forest and other woody biomass stocks* – the most important effects of human interactions with existing forests are considered in a single, broad category, which includes commercial management, harvest of industrial roundwood (logs) and fuelwood, production and use of wood commodities, and establishment and operation of forest plantations as well as planting of trees in urban, village and other non-forest locations;
- *Forest and grassland conversion* – the conversion of forests and grasslands to pasture, cropland or other managed uses can substantially change carbon stores in vegetation and soil;
- *Abandonment of croplands, pastures, plantation forests, or other managed lands* – which regrow into their prior natural grassland or forest condition;
- *CO₂ emissions and removals from soils* – this category covers CO₂ emissions or removals from:
 - i) cultivation of mineral soils,
 - ii) cultivation of organic soils, and
 - iii) liming of agricultural soils.

The IPCC Guidelines briefly describe general issues and methodological approaches for other possible categories, such as natural disturbances (including fire), shifting cultivation, and flooding and drainage of wetlands. The inventory estimates:

- CO₂ emissions/removals in the above four categories;
- Immediate release of non-CO₂ trace gases (CH₄, CO, N₂O and NO_x) from open burning of biomass from forest clearing.

The approach, methodology and steps involved in estimating a GHG inventory in the LULUCF sector using the IPCC default methods are as follows:

- *Step 1:* The Revised 1996 IPCC Guidelines do not provide a key category analysis approach. However, inventory experts are encouraged to conduct key category analysis using the *Good Practice Guidance for Land Use, Land-Use Change and Forestry* (hereinafter referred to as the IPCC good practice guidance for LULUCF), where the LULUCF sector is compared to other source sectors, such as energy, agriculture, industrial processes and waste. Firstly, estimate the LULUCF sector's share of the national GHG inventory. Key source/sink sector identification could be adopted by Parties who have already prepared their initial national communications, and have the inventory estimates. Parties that have not prepared an initial national communication can use inventories prepared under other programs. Parties that have not prepared any inventory, may not be able to carry out the key source/sink sector analysis;
- *Step 2:* Select the land use categories (forest/ plantations), the vegetation types subjected to conversion (forest and grassland), and the land-use/management systems (for soil carbon inventory);
- *Step 3:* Assemble the required activity data, depending on the tier selected, from local, regional, national and global databases, including the EFDB;¹⁸
- *Step 4:* Collect emission/removal factors, depending on the tier level selected, from local, regional, national and global databases, including EFDB;
- *Step 5:* Estimate the uncertainty involved;
- *Step 6:* Report GHG emissions and removals;
- *Step 7:* Report all the procedures, equations and sources of data adopted for the GHG inventory estimation.

¹⁷ Available at <<http://faostat.fao.org/?alias=faostatclassic>>.
¹⁸ <<http://www.ipcc-nggip.iges.or.jp/EFDB/main.php>>.

4.4.2 CHOICE OF ACTIVITY DATA

Various sources of data may be used to quantify GHG emissions in the LULUCF sector. In practice, activity data are most commonly acquired from datasets that have already been prepared for different purposes. When this is done, the datasets should be combined into a unified dataset which covers all aspects of the LULUCF category, as defined in the IPCC Guidelines. A land-use survey may be conducted in order to provide a national or regional assessment while a complete mapping would yield the most comprehensive dataset.

- Tier 1: Nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land-cover maps
- Tier 2: Activity data defined by the country for the most important land uses/activities. This level requires higher resolution activity data to correspond to specific regions and land-use categories
- Tier 3: Very high resolution data, often obtained from a global information system (GIS) -based (or similar) source to acquire data from a fine grid

4.4.3 CHOICE OF EMISSION FACTOR

- Tier 1: The default emission factors provided in the IPCC Guidelines;
- Tier 2: Applies emission factors defined by the country for the most important land uses/activities;
- Tier 3: Derived emission factors from models and inventory measurement systems

4.5 WASTE

Approximately 10–23 per cent (IPCC Guidelines, 2001) of annual global anthropogenic CH₄ produced and released into the atmosphere is a by-product of the anaerobic decomposition of landfilled waste. Wastewater treatment may account for another 10 per cent of anthropogenic CH₄ emissions, both from domestic and industrial waste sources. From industrial sources, pulp and paper, as well as food and beverage, processing industries account for most of the emissions.

4.5.1 CHOICE OF METHOD

The IPCC Guidelines provide approaches, methodologies and technical guidance for preparing a GHG inventory for the Waste sector. The fundamental basis for the inventory methodology rests upon three assumptions:

- i. The flux of CH₄ to the atmosphere is assumed to be equal to the sum of emissions from solid waste disposal sites, wastewater treatment and emissions from waste incineration (considered to be negligible);
- ii. The flux of N₂O to the atmosphere is assumed to be equal to the sum of emissions from wastewater treatment and emissions from waste incineration;
- iii. CO₂ can be estimated by first establishing the rates of organic content in waste incinerated.

This requires the estimation of the amounts and composition of waste and wastewater produced and treated each year, and the conditions in which the treatment is applied.

The IPCC Guidelines provide a default approach, methodology and default data for a GHG inventory for the Waste sector. The default approach involves estimating the GHG inventory using three categories, namely:

Land disposal of solid waste: The common, most important effects of human in waste production are considered in a single broad category, which includes household, yard/garden, and commercial/market as well as industrial waste if it is significant.

Wastewater handling: The CH₄ emissions from activities that should be calculated separately are from: domestic and commercial wastewater, and industrial wastewater, including sludge streams.

Nitrous oxide from human sewage – which uses a method developed for the Agriculture sector.

The IPCC Guidelines briefly describe general issues and methodological approaches for other possible categories such as waste incineration (for this category it is explained that if the waste is used directly as fuel or converted into a fuel, then emissions should be calculated and reported under the Energy sector). CO₂ emissions from decomposition

of organic materials are assigned to the Agriculture and Land-Use Change and Forestry sectors. It is also recognized that no method is provided to calculate NMVOC. The inventory contains:

- CH₄ emissions from the first two categories mentioned above;
- N₂O from human sewage.

4.5.2 CHOICE OF ACTIVITY DATA

Solid waste generation is the common basis for data used to quantify GHG emissions from solid waste disposal, biological treatment, and incineration and open burning of waste. Data collection practices are divided into four subcategories: municipal solid waste (MSW), sludge, industrial and other waste.

MUNICIPAL SOLID WASTE

- Tier 1: Although not mandatory, default data for region-specific per capita MSW generation and management practices are provided in the 2006 IPCC Guidelines, Volume 5;
- Tier 2: It is good practice to apply country-specific data (region-specific for large countries) on MSW generation and management practices for inventory estimation. The data may be obtained from sources such as waste statistics, surveys, and research projects.
- Tier 3: Data can be acquired from waste-stream analysis, by observing and analysing waste as it moves between steps in the MSW treatment process. This approach should be combined with high quality country-specific data.

SLUDGE

Default data for sludge generation are not available and, as such, country-specific data should be used to estimate GHG emissions from sludge generation; however, this data may also be unavailable. If no country-specific data are readily available, the multi-tier methodology presented in the 2006 IPCC Guidelines, Volume 6 may be applied; this guidance uses the total amount of organically degradable material in waste.

INDUSTRIAL WASTE

- Tier 1: Although not mandatory, default data for industrial waste are provided in the 2006 IPCC Guidelines, Volume 5 for some countries, countries for which default data are not available should use data from a country or multiple countries in a similar situation;
- Tier 2: It is good practice to apply country-specific data for industrial waste generation, waste composition and management practices for inventory estimation. The data should be collected and divided by industry type;
- Tier 3: Data can be acquired from waste-stream analysis, by observing and analysing waste as it moves between steps in the MSW treatment process. Data can be collected using surveys of collected on a plant-by-plant basis.

OTHER WASTE

GHG emissions from other sources of waste, including *clinical waste* and *hazardous waste*, appear to be insignificant in most countries. Should countries wish to include these waste sources, carbon content data are provided in the 2006 IPCC Guidelines, Volume 5. Carbon content data for *agricultural waste* can be found in the 2006 IPCC Guidelines, Volume 4.

4.5.3 CHOICE OF EMISSION FACTOR

Emission factors are derived from the degradable organic carbon (DOC) in waste that is accessible to biochemical decomposition. Although not mandatory, default DOC values are provided in the 2006 IPCC Guidelines, Volume 5. Parties are, however, encouraged to use country-specific values if available. Country-specific data may be obtained by sampling at solid waste disposal sites with analysis of the DOC within the country.

V. QUALITY CONTROL AND COMPLETENESS

Quality control (QC) and completeness are important not only for the reliability of the inventory results, but also for providing a reliable comparison from one year to the next. The quality and completeness of the inventory should be as high as possible, with continuous improvements and retroactive corrections when new data become available.

Before finalizing their inventory submissions, countries should consider the following QC and completeness issues with regard to *fuel combustion*:

- Have estimates for all gases (CO₂, CH₄ and N₂O), source categories, and sub-source categories been provided?
- Have emissions from all of its territory, including territories and islands abroad been included?
- Have emissions from bunker fuels been reported under the Memo Items section of the Summary tables and in the sectoral reporting table for the Energy sector?
- Have all fossil-fuel-fired power plants been included in the country's emission estimates?
- Have emissions due to the combustion of fuels in the iron and steel industry been reported in the Energy sector as requested in the Revised 1996 IPCC Guidelines?
- Does the inventory avoid any double-counting or omission of emissions from blast furnaces and coke production (i.e. if allocated to the Industrial Processes sector have emissions been excluded from Energy sector)?
- Does the inventory report emissions from waste combustion with energy recovery under the Energy sector? Do the CO₂ emission estimates from this waste combustion exclude the fraction of biogenic carbon in the waste?

Companies in the oil and natural gas industry often burn unprocessed or partially processed natural gas for fuel (i.e. non-marketable fuel). The consumption of these fuels may not be accounted for in sectoral consumption statistics. For instance, consumption of non-marketable gas is much less likely to be metered and may have substantially different carbon factors and calorific values than marketable gas, due to greater concentrations of impurities and heavier-than-methane hydrocarbons.

Compressor stations on gas transmission systems may not necessarily meter the fuel they draw from the pipeline. In these cases, fuel consumption at the compressor stations is either estimated based on equipment duties, or counted as normal process shrinkage. Although not as common, similar situations can occur on oil transmission pipelines, where product may sometimes be drawn from the pipeline to fuel the pumps. Theft, particularly from natural gas systems, may be a significant unaccounted source of fuel use in some countries.

In theory, a thorough comparison of reference and sectoral approach calculations should identify many completeness issues. In practice, however, the energy statistics used for both approaches tend to come from similar government statistics, and therefore are likely to contain similar errors.

VI. UNCERTAINTY

Uncertainty estimates are an essential element of a complete emissions inventory. Uncertainty information is not intended to dispute the validity of the inventory estimates, but to help prioritize efforts to improve the accuracy of inventories in the future and guide decisions on methodological choice.

There are many reasons that actual emissions and sinks may differ from the number calculated in a national inventory. Some sources of uncertainty (i.e. sampling error or limitations on instrument accuracy) may generate well-defined, easily characterized estimates of the range of potential error. However, other sources of uncertainty may be much more difficult to characterize.

Ideally, emissions estimates and uncertainty ranges would both be derived from source-specific measured data. Since it is not practical to measure every emission source in this way, estimates are often based on the known characteristics of typical sources taken to be representative of the population. This introduces additional uncertainties, because it must be assumed that the population of these sources behave, on average, like the sources that have been measured. Sometimes enough will be known about these typical sources to determine their uncertainty distributions empirically. In practice, however, expert judgement will often be necessary to define the uncertainty ranges.

The pragmatic approach to producing quantitative uncertainty estimates in this situation is to use the best available estimates: a combination of the available measured data and expert judgement. Detailed guidance on how to assess uncertainties is provided in the IPCC good practice guidance and the IPCC good practice guidance for LULUCF.

The estimation of uncertainty uses two key statistical concepts:

- The probability density function – the range and likelihood of possible values;
- Confidence limits (or confidence interval) – the range within which a value is expected to lie for a specified probability. The IPCC Guidelines suggest a 95 per cent confidence interval (CI).

Appropriate statistical tests should be applied, based on the factor being examined and the data available for assessment, with the key variable being sample size. Annex 1 of the 2000 IPCC good practice guidance provides some guidance on selection of statistical distribution for uncertainty assessment, but expert judgement will often be required. Expert judgement involves the forming of an estimate of uncertainty by a person who has special skills or knowledge of the particular field and often will require both statistical and technical experts.

Upon the determination of individual uncertainties (activity level, emission factors, and other variables for each source category), uncertainties must be combined in order to provide uncertainty estimates for the entire inventory. Guidance on the combination of uncertainties is provided in the 2000 IPCC good practice guidance.

VII. NATIONAL COMMUNICATION OF NON-ANNEX I PARTIES

According to Article 4.1 (a) of the Convention, all Parties shall develop, periodically update, publish and make available to the Conference of the Parties (COP), national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the COP.

7.1 UNFCCC GUIDELINES FOR NON-ANNEX I NATIONAL COMMUNICATIONS AND USER MANUAL

According to Article 12.1 of the Convention, each Party shall communicate to the COP three elements of information:

- A national inventory of anthropogenic GHG emissions by sources, and removals by sinks;
- A general description of steps taken or envisaged by the Party to implement the Convention;
- Any other information the Party considers relevant to the achievement of the objectives of the Convention.

Guidelines for the preparation of national communications were adopted at COP 8 and are available in the annex of decision 17/CP.8. To facilitate the use of decision 17/CP.8 and assist Parties and national experts in preparing national reports, the secretariat developed a user manual (*Reporting on Climate Change: User Manual for the Guidelines on National Communications from Non-Annex I Parties*)¹⁹

7.2 FINANCIAL AND TECHNICAL ASSISTANCE

Both financial and technical assistance can be provided through the UNFCCC to ensure that non-Annex I Parties have the necessary resources to complete accurate and reliable national reports.

Financial assistance is provided by the Global Environmental Facility (GEF) through its implementing agencies (such as the United Nations Development Programme, the United Nations Environment Programme and the World Bank). More information on this issue is available in Module 1 of the Resource Guide (*"The Process of National Communications from non-Annex I Parties"*).

¹⁹ The User Manual is available at <http://unfccc.int/national_reports/non-annex_i_natcom/guidelines_and_user_manual/items/2607.php>.

VIII. UNFCCC NON-ANNEX I GREENHOUSE GAS INVENTORY SOFTWARE²⁰

The UNFCCC secretariat has produced an Excel-based software program to facilitate the task of including the inventory sectoral tables and worksheets in national communications. The software is designed to be used alongside decision 17/CP.8 to assist non-Annex I Parties in the compilation of their national GHG inventories and in the preparation of their national communications. In order to be as flexible as possible, the software incorporates all the elements that a national inventory may contain. It can also aid the process of documenting source-by-source information, as well as archiving data for several years.

The GHG inventory software is designed in seven modules, and also has an initialized routine, and an overview. All worksheets have protected cells, so that only cells requiring user input may be changed.

The software is to be used in conjunction with:

- Decision 17/CP.8;
- The Revised 1996 IPCC Guidelines;
- The IPCC good practice guidance for LULUCF (where appropriate).

The use of the software results in:

- Complete national GHG inventory reports;
- Completed tables to be included in national communications.

Accuracy:

- The software uses Tier 1 (lowest accepted accuracy) methodologies for estimating GHG emissions and removals.

The UNFCCC has prepared a complete user manual to provide support for users of the non-Annex I GHG inventory software. The manual, which is available to the public on the UNFCCC website, provides introductory information about the software as well as step-by-step instructions for completing each module.

²⁰ The latest version is 1.3.2 and is available at http://unfccc.int/resource/cd_roms/na1/ghg_inventories/index.htm.

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