ANNEX 3 SUMMARY OF THE REVISED 1996 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES

A3.1 Background

This Annex summarises additions and revisions to the *1995 IPCC Guidelines for National Greenhouse Gas Inventories* (*1995 IPCC Guidelines*). It also describes efforts made by the IPCC to harmonise methods with others. The additions and revisions were accepted by the IPCC at its Twelfth Session held in Mexico City (11-13 September 1996) after acceptance by Working Group I at its Sixth Session held in Mexico City (10 September 1996) in accordance with IPCC procedures. They are called the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.* Within this Annex, a revision of an existing methodology or default data is referred to as a *'revision', 'revised method'* or *'revised data'.* Additional methods and default data are defined as *'new'* methods or *'new data'.*

A3.2 Energy

The Energy Chapter contains the following improvements and additions:

- Harmonisation of international (IPCC and CORINAIR) emission estimation methodologies and allocating of emissions from autoproducers[1] to the sector where they are generated and not to the transformation[2] sector (*revision);*

- Development of a *new* Tier 1 method for estimating non-CO_2 Greenhouse Gas (GHG) and SO_2 emissions based on fuel consumption;

- Development of a *new* Tier 2 method for estimating emissions from aircraft;

- Inclusion of *new* default values for various types of traditional biomass fuels;

- Clarification of the definition of National Navigation (the definition of International Marine Bunkers remains unchanged).

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[1] An autoproducer is defined as an entity which produces electricity and/or heat for sale in addition to its primary activities.

[2] The transformation sector comprises the conversion of primary forms of energy to secondary and further transformation (e.g. coking coal to coke, heavy fuel oil to electricity)

A3.3 Industrial Processes

The Industrial Process Chapter contains a broad range of *new* estimation methodologies for the so-called "new gases", that is perfluorocarbons, PFCs (e.g. CF_4 and C_2F_6), HFCs (e.g. HFC-125 and HFC-134a), sulphur hexafluoride (SF_6), the direct GHG (CO_2, CH_4, and N_2O), and ozone and aerosol precursors (SO_2, NOx, CO, NMVOC) from industrial, non-energy, processes.

Direct GHG: The *new* methodologies cover CO_2, CH_4, and N_2O emissions from the production of mineral compounds, chemical industries and metal manufacture. The estimation of CO_2 emissions from cement production remains unchanged, but the methodologies for N_2O emissions from nitric and adipic acid production have been revised.

Aerosol and ozone precursors: For SO_2, NOx, CO, NMVOC, *new* methodologies are presented, which draw upon and improve existing international methodologies. The sectors covered are: mineral compounds production, chemical industries and metal manufacture.

Fluorocarbons and SF₆: For HFCs and PFCs, and SF_6, methodologies are provided to estimate by-product and fugitive emissions from aluminium (Al) and magnesium (Mg) manufacturing processes, as well as emissions from their production and consumption. Two approaches are given: Tier 1 (a, b) for *potential* emissions, and Tier 2, for *actual* emissions. *Potential emissions* of PFCs, HFCs, and *SF₆:* are equal to the amount of a chemical consumed in a country, minus the amount of a chemical recovered for destruction or export in the year of consideration. *Actual* emissions estimates take into account the time lag between consumption and emissions. The Tier 2 methodology is, therefore, the more accurate estimation approach.

A3.4 Land-use Change and Forestry

Several revisions to the methods for the Land-use Change and Forestry Chapter are provided. One such revision is to the method for estimating CO_2 fluxes from soils, as described below.

The *revisions* to the Land-use Change and Forestry Chapter greatly extend and improve the range and quality of default data, particularly for the tropics, where national forestry statistics are sometimes less accessible than in the temperate or boreal regions. The *revisions* can be summarised by changes in (a) default data and in (b) methods, as follows:

Default data

Classification system for land cover types: A *revised* system more consistent with sources of national, regional and international data, such as forest conversion rates and forest inventories was developed. The *revised* classification system better reflects the diversity of forest types. For the tropics, three classes of forests have been replaced with six, based on differences in rainfall amount, seasonality, and altitude.

Rates of forest conversion: *New* FAO default data are provided for each country and forest type according to the proposed land-cover classification

system. These data have been compiled for the tropics for the 1980-90 period. Such *revisions* were incorporated because country-level data are often difficult to obtain for many tropical countries; the *1995 IPCC Guidelines* contain no such data.

Aboveground biomass for native tropical forests: Emissions estimates from land-use change and forestry can be highly sensitive to such input data and therefore a priority was given to improving aboveground biomass data. Since publication of the *1995 IPCC Guidelines*, better datasets have become available drawing upon larger regional studies. The *revisions* now include a large database of default values for Africa, America, and Asia for the *revised* land-cover classification system. Additional data based on individual forest inventories (suitable for converting to biomass) for many tropical countries are also included. None of the default values are separated into primary and secondary forests (as in *1995* IPCC *Guidelines)* because it was felt by experts that this was not a practical classification, given the variability of definitions in different regions.

Rates of tropical forest regrowth: *Revised* default data are given for forest regrowth; the data are related to the biomass data and are reported for the three tropical regions by forest type, according to the *revised* classification system.

Methods

Estimation of net CO_2 emissions from soil carbon: In the *1995 IPCC Guidelines*, CO_2 estimates are based upon the product of the rate of change in area of a given land-use and the rate of change of soil carbon. The *revised* method estimates changes in soil carbon pools associated with altered land-use or land management practices. Thus, all categories of agriculturally-impacted lands, including conversions of forest or other vegetation to agriculture, land abandonment, shifting cultivation and permanent agriculture, are included in the methodology. A default stock method is employed to estimate CO_2 fluxes associated with agricultural activities for a 20-year inventory period. This area of the IPCC Methodology has been much improved because better scientific data is now available. The *revised* method is more compatible with potential policy analysis.

A3.5 Agriculture

Three sections of this Chapter have been *revised*, that are, (1) methane emissions from rice cultivation, (2) nitrous oxide emissions from agricultural soils and (3) manure management. For the estimation of N_2O emissions, the default methods and data are *new*.

Methane Emissions from Rice Cultivation

In the *1995 IPCC Guidelines*, the estimation of CH_4 emissions from wetland rice cultivation is a function of the CH_4 emission factor, area of rice cultivated and the season length. One critical default parameter is the CH_4 emission factor, which is based upon temperature. It was determined that the relationship between CH_4 emissions and soil temperature as assumed in

the *1995 IPCC Guidelines* was no longer appropriate because new data suggest that the seasonally integrated CH_4 flux depends much more on the input of organic carbon, water regime, time and duration of drainage and soil type than on local temperature. The *revised* methodology is a function of the emission factor integrated over a cropping season for particular rice water regime, for a given organic amendment, and of the annual harvested area cultivated under these conditions. The latter is given by the cultivated area times the number of cropping seasons per year.

The *revisions* to the method use internationally-agreed definitions for rice eco-systems classified according to the water regime and a range of CH_4 emission scaling factors relative to continuously flooded rice eco-systems and for soils without organic amendment. A default seasonally integrated emission factor is also provided for the continuously-flooded regime, without-organic amendment.

Nitrous Oxide Emissions from Agricultural Soils and Manure Management

A *new* default method for calculating national emissions of N_2O from agriculture is provided. The *new* N_2O method is a revision of the method in the *1995 IPCC Guidelines.* It includes more sources of N_2O from agricultural activities and makes explicit recommendations on N_2O emission factors. The *new* method accounts for the application of N-fertilisers to the soil and N uptake in crops and subsequently tracks the flow of N as it moves through the (anthropogenic) animal and human food chain. Three categories of N_2O sources are distinguished in the *new* methodology, (1) direct emissions from agricultural soils, (2) emissions from animal production, and (3) N_2O emissions indirectly induced by agricultural activities[3]. Because a larger number of sources and pathways are considered, the *new* N_2O methodology affects several source sectors. Emissions are reported in several sections of the 1995 *IPCC Guidelines*, namely, Manure Management (Section 4.2, 1995 *IPCC Guidelines*), Agricultural Soils (Section 4.5, *1995 IPCC Guidelines*), and Waste (Section 6.3, *1995 IPCC Guidelines*). The input data required can be obtained from FAO databases.

The *new* method provides a comprehensive description of N_2O emissions from agriculturally-related activities by accounting for previously omitted N_2O sources. Using this method, global N_2O emission estimates imply that atmospheric N_2O input from agricultural production as a whole has apparently been previously underestimated by at least 70%. Nitrous oxide emissions resulting from atmospheric deposition are assigned to the NO_x or NH_3 emitting country[4].

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[3] It is however recognised that there are other sources of anthropogenic atmospheric inputs of N-compounds to soils e.g., NO_x from fuel combustion. Only compounds directly applied to agricultural soils are considered.

[4] In some countries and regions, other conventions related to long range transboundary air pollution are addressing the issue of atmospheric transport and deposition in greater detail.

A3.6 Waste

The Chapter on Waste addresses various topics, including: improved waste disposal data, evaluation of the methodologies for solid waste and wastewater, definitions of activities and uncertainties of CH_4 emission estimates. The main improvements to the methods and default data are as follows:

Solid Waste

Site classification: A *new* term - solid waste disposal site - has been proposed to refer to all sites and to replace the terminology in *1995 IPCC Guidelines* for 'landfills' and 'open dumps'. The *new* term was proposed because experience suggests that the existing categories do not adequately include the entire range of waste disposal sites that exists in all countries. Solid waste disposal sites include all sites where waste is deposited and is likely to generate some methane. Sites are further classified according to the level of site management and depth.

Methane correction factor: The *new* site classification is used to derive a methane correction factor (MCF) to account for the methane generation potential of the site. The amount of methane produced depends in part upon the available oxygen and the level of compaction of the waste. In general, waste in managed sites potentially generates more methane than waste in unmanaged sites. Furthermore, the deeper the site, the greater the methane generation potential. The methane correction factor for each type of site reflects these differences in methane generation potential. The site classification recognises that some developing countries, or countries with-economies-in-transition, may have a majority of less-well managed or unmanaged sites, often with a lower methane-producing potential than well managed sites.

Waste data: A wide range of *revised* and *new* default data on waste generation, composition and disposal data in many additional developed and developing countries is provided. A definition for Municipal Solid Waste and a method for calculating the Degradable Organic Carbon content of various waste streams are now included in the *revised* Chapter.

Methodology: The default methodology was evaluated and retained. The methodology uses a zero-order equation requiring data on population, waste landfills, and waste composition as proposed by Bingemar and Crutzen (1987).

Wastewater

A *revised* method and default data for calculating emissions from wastewater and sludge is included. The amount of CH_4 produced from these systems depends upon several factors, including the characteristics of the wastewater and the management system, and temperature. These factors are highly dependent upon the waste treatment system used. The *revised* methodology allows countries to tailor the estimation approaches more precisely to their wastewater management systems. This is accomplished by the MCF that accounts for the differing CH_4 generating potential of

different wastewater management systems. In addition, the *revised* methodology uses data that is commonly available from most countries, or which can be estimated by wastewater experts.

Human sewage

A *new* methodology and default data are provided for the estimation of N_2O nitrous oxide emissions from human sewage disposed to land, and in subsequent run-off to rivers and estuaries. There is no such methodology in *1995 IPCC Guidelines.*

A3.7 Harmonisation of International Emission Estimation Methodologies

Progress has been made in the harmonisation of the IPCC and EMEP/CORINAIR methodologies to allow more direct comparison of the two approaches. These changes are mainly in the Energy Chapter, but harmonisation was a theme in all other chapters, including Industrial Processes. Examples of harmonisation are given below from the Energy Chapter:

- Biomass fuels are allocated to the various source categories *(new)*. As in *1995 IPCC Guidelines*, CO_2 from biomass will not be reported in national totals as this is captured in the Land-use Change and Forestry Chapter

- Emissions from fuel used for electricity and heat production by autoproducers will be included in the sector where it is generated and not with the transformation industries.

- Treatment of evaporative emissions (NMVOCs) from road transport in the Tier 2 method of IPCC is made consistent with CORINAIR. Combustion and evaporative emissions are to be reported separately. However, in the *new* Tier I IPCC method, all emissions from road transport are included together under fuel combustion.

- Development of a *new* Tier 2 method for estimating emissions from aircraft.

References

Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks (1996).

Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook (1996), 1st Edition, European Environmental Agency.

1995 IPCC Guidelines for National Greenhouse Gas Inventories, Reporting Instructions (Volume 1); Workbook (Volume 2); Reference Manual (Volume 3).

Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories

Sector[1]	Volume	Chapter/Section	Summary of additions/revisions[2]
1. Energy	Reference Manual (Volume 3)	Chapter 1, Energy	Main changes are : • assignment of GHG emissions from autoproducers to the sector where they were generated and not to the transformation sector (revision); • development of a Tier 1 method for estimating non- CO_2 GHG and SO_2 emissions based on fuel consumption (new); • development of a Tier 2 method for estimating emissions from aircraft (new); • inclusion of default values for various types of traditional biomass fuels (new); • clarification of the definition of National Navigation (the definition of International Marine Bunkers remains unchanged)
	Workbook (Volume 2)	Module 1, Energy	
2. Industrial Processes	Reference Manual (Volume 3)	Chapter 2, Industrial Processes	New methods and default data for the estimation of emissions of • direct greenhouse gases (CO_2, CH_4, and N_2O) and SO_2 from: - mineral production; - chemical industries; - metal manufacture. • ozone precursors (NOx, CO, NMVOC) from : - chemical industries - metal manufacture • halocarbons (PFCs, HFCs) and sulphur hexafluoride (SF_6) from metal manufacture, use and production. - Tier 1 (a): for bulk chemicals; - Tier 1 (b): for bulk chemicals and chemicals stored in products; - Tier 2 : product (containing PFCs, HFCs, SF_6) lifetimes are taken into account.
	Workbook (Volume 2)	Module 2, Industrial Processes	

1 Chapter 3, "Solvents and other product use" has not been revised.
2 A revision of an existing methodology or default data is referred to as a 'revision'. In cases where an additional method has been developed and default data provided, this is defined as 'new'.

Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (continued)

Sector[1]	Volume	Chapter/Section	Summary of additions/revisions[2]
4. Agriculture	Reference Manual (Volume 3)	Chapter 4: Agriculture, Methane Emissions from Rice Cultivation	• Revised method and new default data for the estimation of Methane Emissions from Rice Cultivation uses: - internationally-agreed definitions of rice ecosystems (revision); - default data (e.g. seasonally integrated CH_4 emission factors) (new); - scaling factors for CH_4 emissions factors relative to continuously flooded fields (without-organic amendment) (new).
	Reference Manual (Volume 3)	Chapter 4: Agriculture, Agricultural Soils and Manure Management	Additions and revisions include: • default method for the estimation of nitrous oxide emissions from Manure Management and Agricultural soils (new); • revised default emission factors for the estimation of direct emissions of N_2O from soils (revision); • default data (e.g. N_2O emission factors for animal waste and for indirect emissions) (new).
	Workbook (Volume 2)	Module 4 : Agriculture Agricultural Soils, Manure Management, and Methane Emissions from Rice Cultivation	
5. Land-use Change & Forestry	Reference Manual (Volume 3)	Chapter 5, Land-use Change & Forestry	• Revised /new default data and classification are suggested for: - land-cover types (revision); - rates of forest conversion (new); - aboveground biomass for native tropical forests (revision); - rates of tropical forest regrowth (revision) • Method for the estimation of CO_2 fluxes from agricultural soils (revision) and default data (new).
	Workbook (Volume 2)	Module 5, Land-use Change & Forestry	

1 Chapter 3, "Solvents and other product use" has not been revised.
2 A revision of an existing methodology or default data is referred to as a 'revision'. In cases where an additional method has been developed and default data provided, this is defined as 'new'.

Table 1. Additions/revisions to the 1995 IPCC Guidelines for National Greenhouse Gas Inventories (continued)

Sector[1]	Volume	Chapter/Section	Summary of additions/revisions[2]
6. Waste	Reference Manual (Volume 3)	Chapter 6, Waste	• Solid waste disposal Revised/new data and classification are listed below for: - solid waste disposal site classification: definition encompasses all sites classified in the current Guidelines (revision); - methane correction factor to account for the methane generation potential of the site (new); - wider range of default data for waste generation, composition and disposal data (revision). • Wastewater - revised approach and default data for calculating CH_4 emissions (revision). • Human sewage - method and default data for the estimation of N_2O emissions (new).
	Workbook (Volume 2)	Module 6, Waste	

1 Chapter 3, "Solvents and other product use" has not been revised.

2 A revision of an existing methodology or default data is referred to as a 'revision'. In cases where an additional method has been developed and default data provided, this is defined as 'new'.