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(IGCE)

GHG emissions inventories in energy sector

Main Contents of 2006 IPCC Guideline - Vol.2 (Energy)

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1. Energy sector
general issues

Energy sector

1A. FUEL COMBUSTION

Sectoral approach

- Stationary combustion (1A1, 1A2, 1A4, 1A5),
- Mobile combustion (1A3, 1.A.4.c.ii, 1.A.4.c.iii, 1.A.5.b)
- Memo items:
bunker fuel, biofuel

Reference approach

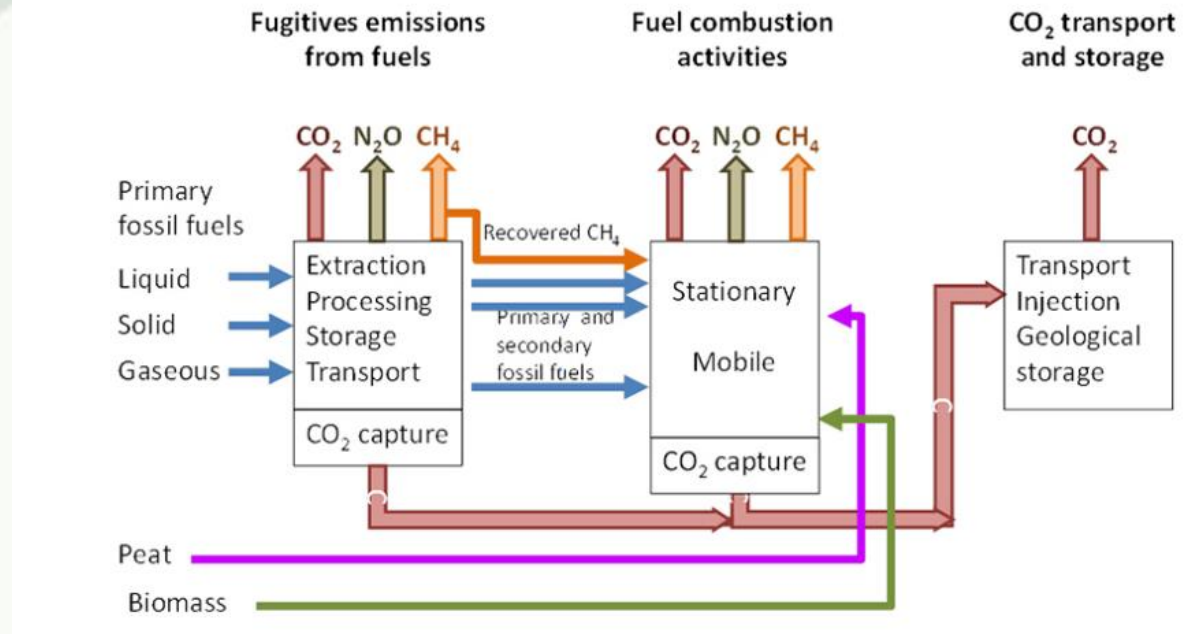
1B. Fugitive emissions:

- Solid fuels (1.B.1)
- Oil and gas (1.B.2)

1C. CO₂ transport and storage

GHGs considered in Energy sector:

Carbon dioxide (CO₂)
Methane (CH₄)
Nitrogen oxide (N₂O)



The energy sector mainly comprises:

- exploration and exploitation of primary energy sources,
- conversion of primary energy sources into more useable energy forms in refineries and power plants
- transmission and distribution of fuels
- use of fuels in stationary and mobile applications.



1A. Fuel combustion

1A Fuel combustion

For inventory purposes, **fuel combustion** may be defined as the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus.

Sectoral approach- the main method for estimating emissions from the combustion of fuel and energy resources is the calculation of emissions by sectors of the economy

Reference approach - based on the total consumption of fuel and energy resources in the country and is used to independently verify the completeness and correctness of the calculations of the sectoral approach

Methodological approaches to estimating emissions for the sectoral approach differ for

Stationary fuel combustion sources

- Energy industries (1.A.1)
- Manufacturing industries and construction (1.A.2)
- Other sources (1.A.4), including
 - commercial and institutional,
 - residential,
 - forestry, agriculture and fishing
- Other (1.A.5)

Mobile sources (1.A.3)

- Civil aviation
- Road transport
- Railway transport
- Navigation
- Other transportation (including pipelines)

Fuel type

Solid fuel

Primary fuels: Anthracite, coking coal, hard coal, lignite

Secondary fuels: coal briquettes, oil shale, combustible artificial coke oven gas, combustible artificial blast-furnace gas, metallurgical coke, coal tar

Other fuels

Abiogenic waste
Industrial waste
Oil waste

Biomass

Fuel wood, charcoal, biogenic waste

Gas fuel

Natural gas

Liquid (Crude oil and petroleum products)

Primary fuels: Crude Oil

Secondary fuels: gasoline, kerosene, diesel fuel, fuel oil, liquefied petroleum gas, other motor fuels, refinery gas, petroleum coke, other petroleum products

Peat

It is important to understand that the type of secondary fuels is determined not by the state of aggregation, but by the type of fuel from which they are produced.

A faint, circular logo in the background. It features a stylized tree with a thick trunk and dense foliage on the right side. Below the tree is a blue, wavy shape representing water. The entire logo is set against a light green circular background with a serrated, sun-like edge.

1A. Reference approach

Reference approach _ 1

The Reference Approach:

- is a method that can be applied on the basis of relatively easily available energy supply statistics
- is one of the procedures to verify the completeness and accuracy of the inventory estimates obtained using the Sectoral Approach
- significant differences may indicate possible problems
- National total emissions are determined using the estimates obtained through the Sectoral Approach

To estimate '**total apparent fuel consumption**' in a country, the following data are required for each fuel and inventory year:

- the amounts of primary fuels produced;
- the amounts of primary and secondary fuels imported;
- the amounts of primary and secondary fuels exported;
- the amounts of primary and secondary fuels used in international bunkers
(fuel used by international aviation and sea-borne navigation);
- the net increases or decreases in stocks of primary and secondary fuels.

Cross-cutting issues

The reporting of non-energy and feedstock use of fuels in the fuel combustion sector and the IPPU Sector using the Reference Approach should be coordinated between these two sectors.

Reference approach _2

Methodological approaches to emission estimation

The Reference Approach methodology breaks the calculation of carbon dioxide emissions

from fuel combustion into 5 steps:

Step 1: Estimate Apparent Fuel Consumption in Original Units.

Step 2: Convert to Common Energy Units.

Step 3: Compute the Total Carbon Using the Emission Factors.

Step 4: Compute the Excluded Carbon.

Step 5: Correct for Carbon Un-oxidized and Convert to CO₂ Emissions.

The 'apparent' consumption of PRIMARY FUELS is therefore calculated as:

$$\text{'Apparent' Consumption} = \text{Production} + \text{Imports} - \text{Exports} - \text{International Bunkers} - \text{Stock Change}$$

Total 'apparent' consumption of a SECONDARY FUEL is calculated as:

$$\text{Total 'Apparent' Secondary Consumption} = \text{Imports} - \text{Exports} - \text{International Bunkers} - \text{Stock Change}$$



1A. Sectoral approach

Stationary combustion

(categories 1A1, 1A2, 1A4, 1A5)

A distinction is made between stationary combustion in

- *energy industries (1.A.1),*
- *manufacturing industries and construction (1.A.2)*
- *other sectors (1.A.4)*
 - *commercial and institutional (1.A.4.a)*
 - *residential (1.A.4.b)*
 - *agriculture, forestry, fishing (1.A.4.c)*
- *other not elsewhere specified (1.A.5)*

Emissions from heat and energy generation for producers' own use should be assigned to the source category which includes the key product produced by the plant.

Subcategories 1.A.4 and 1.A.5 also include emissions from mobile sources (such as agricultural or construction machinery).

The methods to be used for estimating emissions from these sources are described in the methodological recommendations on mobile sources, while the emissions are reported for the relevant subcategory

1A 'Stationary

Combustion'

Methodological approaches

Tier 1 is based on the fuels combustion statistics by source categories and IPCC recommended average emission factors (*Equation 2.2, Chapter 2, Volume 2, 2006 IPCC Guidelines*).

Tier 2, like Tier 1, is based on the fuel combustion statistics, yet instead of IPCC recommended emission factors it uses country-specific emission factors (*Equation 2.2, Chapter 2, Volume 2, 2006 IPCC Guidelines*).

Tier 3 is based on either estimated or measured emissions at the facility level (*Equation 2.3-2.5, Chapter 2, Volume 2, 2006 IPCC Guidelines*).

CO₂ emissions

CH₄, N₂O emissions

- Carbon content in fuel

- combustion technology,
- emissions control equipment
- combustion conditions

Key categories

Tier 2 or 3

Methodology

GHGs emissions from stationary combustion

$$\text{Emissions}_{GHG, fuel} = \text{Fuel Consumption}_{fuel} \cdot \text{Emission Factor}_{GHG, fuel}$$

- Emissions $GHG_{,fuel}$ = emissions of a given GHG by type of fuel (kg GHG)
- Fuel Consumption $fuel$ = amount of fuel combusted (TJ)
- Emission Factor $GHG_{,fuel}$ = default emission factor of a given GHG by type of fuel (kg gas/TJ).
- For CO₂, it includes the carbon oxidation factor, assumed to be 1.

Converting physical units to energy units

$$\text{AD (TJ)} = \text{AD (units)} \times \text{C (TJ / units)}$$

AD (TJ) – fuel consumption in TJ;

AD (units) – fuel consumption in physical units;

C (TJ / units) – conversion factor

Total emissions by GHGs

TOTAL EMISSIONS BY GREENHOUSE GAS

$$= \sum_{\text{fuels}} \text{Emissions}_{GHG, fuel}$$

Activity data

- Tier 1 or 2 estimations typically use data obtained from the national statistics;
- Statistical reports submitted by individual enterprises are normally used for Tier 3 estimations, but can also be used for Tier 1 or 2 estimations; yet if this is the case, it is important to check them for completeness and consistency with the national statistical reporting.
- When working with fuel consumption data, it is recommended to use, where possible, the quantities of fuel combusted, rather than the quantities of fuel delivered, and to check data obtained from various sources for completeness and comparability.
- It is not always possible to make a distinction in the energy statistics between fuels combusted by mobile and stationary sources. Indirect data can be used to derive shares of energy use for each of these sources

It is important to check completeness and consistency of the data used and ensure fuel mass balance

Cross-cutting issues

When choosing activity data it is important to ensure that there is no underestimations or double counting between:

- Energy and IPPU
- Energy and Waste
- Energy and Agriculture, (stationary combustion, mobile combustion, fugitive emissions)

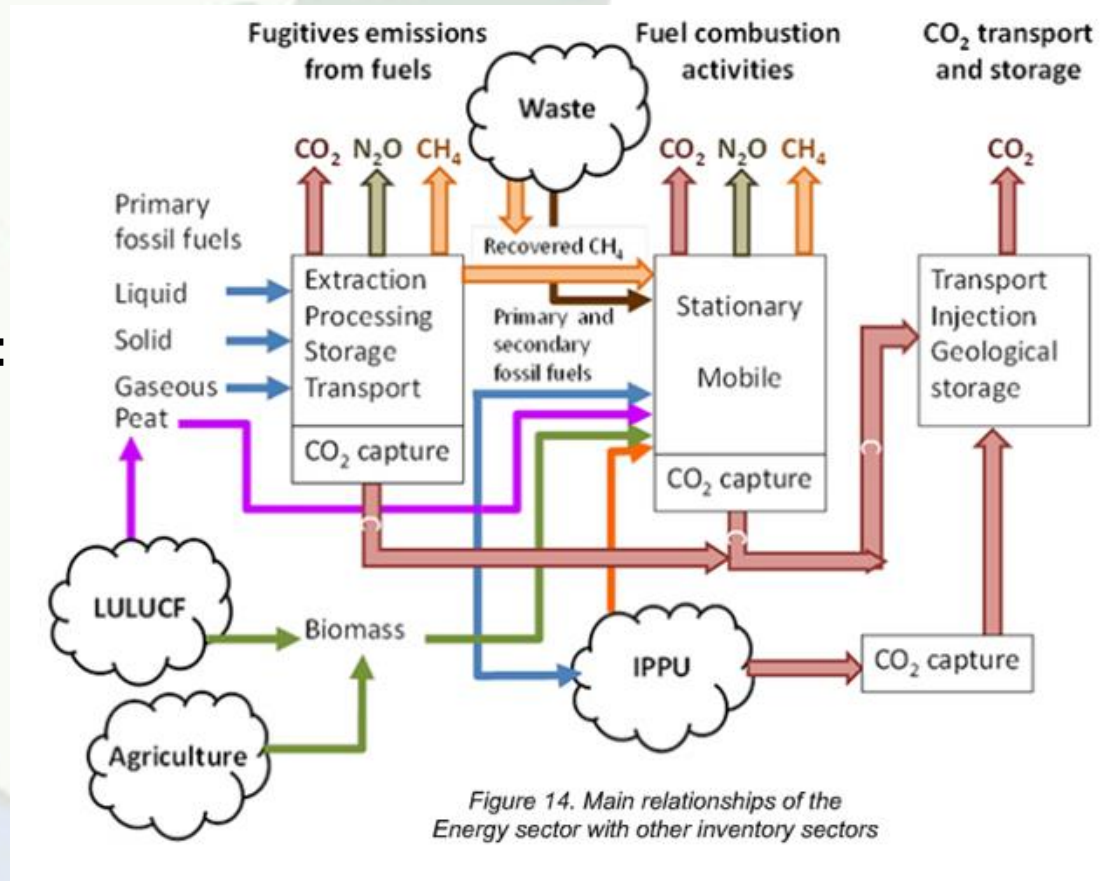


Figure 14. Main relationships of the Energy sector with other inventory sectors

1.A.1. Energy industries

1A1a 'Main Activity Electricity and Heat Production

Where the activity data are available, it is essential to distinguish between

1A1ai – Electricity generation (only electricity generation companies),

1A1aii – Combined Heat and Power Generation (combined cycle producers),

1A1aiii - Heat Plants (only heat producers)

1A1b – Petroleum Refining

This subcategory includes all combustion activities supporting the refining of petroleum products, including on-site combustion for the generation of electricity and heat for own use. Not included fugitive emissions at refinery.

This emission is reported under 1B.2.a.

1A1c – Manufacture of Solid Fuels and Other Energy Industry

Where the activity data are available, it is essential to distinguish between

1.A.1ci - Manufacture of Solid Fuels (emissions arising from fuel combustion for the production of coke, brown coal briquettes, and patent fuel),

1.A.1cii - Other Energy Industries (includes emissions from fuel combustion for energy purposes for coal mining, oil and gas extraction, and the processing and upgrading of natural gas)

1.A.2. Manufacturing Industries and Construction

1A2a – *Iron and Steel*,
1A2b – *Non-ferrous metals*,
1A2c – *Chemical industry*,
1A2d – *Pulp and Paper*,
1A2e – *Food Processing, Beverages, and Tobacco*,
1A2f – *Non-Metallic Minerals (glass, ceramics, cement, etc.)*,
1A2g – *Transport Equipment*,
1A2h – *Machinery*,
1A2i – *Mining (excluding fuels)*,
1A2j – *Wood and Wood Products*,
1A2k – *Construction*,
1A2l – *Textile and Leather*,
1A2m – *Non-Specified Industry*.

1A2g - Other

Activity data include the amount of fuel combusted by the types of fuel used by plants within the source category.

For example, emissions from fuel combustion in coke ovens within the iron and steel industry should be reported in *1.A.1ci - Manufacture of Solid Fuels*, rather than in *1A2a – Iron and Steel*.

Statistics not always provide information about fuels used as **feedstock** or for **energy purposes** at industrial enterprises.

Important to check cross-data between 1A2 and IPPU sector and compare emissions estimated in IPPU sector with fuel reported as feedstock and fuel reported as combusted.

1.A.4. Other Sectors

1.A.4.a Commercial / Institutional (includes emissions from fuel combustion in commercial and public buildings),

1.A.4.b Residential (includes emissions from fuel combustion in the residential sector, excluding centralized heat and power generation),

1.A.4.c Agriculture/Forestry/Fishing/Fish Farms

If activity data are available, emissions in 1A4c subcategory should be broken down into *1A4ci Stationary*, *1A4cii Off-Road Vehicles and Other Machinery* (emissions from fuels combusted in traction vehicles on farm land and in forests), *1A4ciii Fishing* (emissions from fuels combusted for inland, coastal and deep-sea fishing

It should be noted, that all emissions arising from fuel use by agricultural vehicles on paved roads (for example, trucks that carry agricultural products and belong to agricultural enterprises) should not be reported in category *1A4c*, but in category *1A3b – Road Transportation*.

1.A.5. Other not elsewhere specified

1.A.5.a Stationary (emissions from fuel combustion in stationary sources that are not specified elsewhere)

1.A.5.b Mobile (emissions from vehicles and other machinery, marine and aviation (not included in 1A4cii or elsewhere))

The category **1A5b 'Mobile'** includes emissions from fuel delivered to the country's military, as well as fuel delivered within that country but used by the militaries of other countries that are not engaged in multilateral operations. If sufficient data are available, the category **1A5b 'Mobile'** is broken down into

- **1A5bi 'Mobile (aviation component)'**,
- **1A5bii 'Mobile (water-borne component)'**,
- **1A5biii 'Mobile (other)'**.

Emissions from fuels used in multilateral operations pursuant to the Charter of the United Nations, including emissions from fuel delivered to the military in the country and delivered to the military of other countries, are reported separately under the 'Multilateral operations' as information items and are not included in the national totals.

The category '*Non-Specified*' often includes emissions from processes which cannot be split by the types of economic activity. For example, when energy is recovered from waste combustion, the associated greenhouse gas emissions are reported in the *Energy Sector* under stationary combustion; however, it is sometimes difficult to assign these emissions to this or that stationary combustion category. If this is the case, the CO₂ emission from the fossil-carbon part of the waste can be included in the fuel category '**Other fuels**' within the ***Non-Specified*** category.

Effort should be made to minimize the data reported in the category '*Non-Specified*' by assigning the activity data, as much as practicable, to other inventory categories in accordance with the types of economic activities

MOBILE COMBUSTION

(categories 1A3, 1A4CII, 1A4CIII, 1A5B, memo items: bunker fuel, multilateral operations)



This sub-sector provides guidance on estimating greenhouse gas emissions specific to transport in the following categories:

- **civil aviation** (1A3a);
- **road transport** (1A3b);
- **rail transport** (1A3c);
- **navigation** (1A3d);
- **other modes of transport** (1A3e)
- **pipeline transport** (1A3i)

Mobile sources produce direct greenhouse gas emissions, namely, carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) from the combustion of various fuels, as well as several other pollutants, such as carbon monoxide (CO), non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO₂), particulate matter (PM), and oxides of nitrate (NO_x).

1A3b - Road Transportation

The mobile source category 'Road Transportation' includes all types of light-duty vehicles, such as automobiles and light trucks, and heavy-duty vehicles such as tractor trailers and buses, and on-road motorcycles (including mopeds, scooters, and three-wheelers). These vehicles operate on many types of liquid and gaseous fuels.



Activity data

Tier 1 estimations require information on the fuel sold to road transport in a country; however, these data may be unavailable or unreliable, for they can only provide limited information on fuel consumption by transport, particularly road transport. If this is the case, fuel consumption estimates should be based on the size and structure of vehicle fleet registered in the country.

Tier 2 method differs from Tier 1 in that it estimates fuel consumption by vehicle types.

Tier 3 approach requires detailed data to generate vehicle activity-based emission factors for vehicle subcategories and may involve model runs. Tier 3 requires data on average annual vehicle kilometers travelled for each vehicle subcategory disaggregated by average vehicle age, emission class, fuel, engine capacity, average speed, etc.

Estimated emissions from road transport can be based on two independent sets of data: fuel consumption (Tier 1 and 2) and vehicle kilometers (Tier 3, activity data)

In general, the first approach (by fuel consumption - by all vehicles or by vehicle class) is suitable for estimating CO₂ emissions, and the second (by distance travelled) is suitable for estimating CH₄ and N₂O emissions.

If both datasets are available, it is important to check their comparability, otherwise estimates of different gases may be inconsistent.

A fuel balance check should also be carried out if all vehicle emission calculations are based on mileage data.

More detailed modelling tools are available for estimating emissions from road vehicles using Tier 3 methodology – COPERT model (<http://www.emisia.com/copert>)

1.A.3.a Civil aviation



Greenhouse gas emissions depend on the number of aircraft operations; the types and operation parameters of the aircraft engines; the fuel used; and the length of flight.

Tier 1 is purely fuel-based. It is based on the total amount of fuel used by the aviation (LTO cycle and cruise phase) multiplied by average emission factors.

Tier 2 method is only applicable for jet fuel use in jet aircraft engines. Operations of aircraft are divided into LTO and cruise phases. To use Tier 2 method, the number of LTO operations must be known for both domestic and international aviation, preferably by aircraft type.

Tier 3 methods uses movement data for individual flights and are based on actual flight movement data, either: for Tier 3A origin and destination (OD) data or for Tier 3B full flight trajectory information.

Navigation and aviation

International transportation (bunker fuel)

- Greenhouse gas emissions from domestic and international transport need to be calculated separately;
- Disaggregation into international and domestic traffic should be made on the basis of the starting, intermediate and final destinations of the vessels for each voyage, and not on the nationality or flag of the vessel;
- Emissions from international flights cover cargo and passenger transportation from the territory of a country, regardless of the national jurisdiction of the ship. At the same time, emissions generated as a result of cargo and passenger transportation from foreign countries to the country are not subject to accounting;
- Emissions from domestic flights cover cargo and passenger transportation within the territory of the country regardless of the national jurisdiction of the ship;
- Data on greenhouse gas emissions from fuels used in international transportation are not included in national total emissions. It is reported as Memo item

Rail transport (1A3c)

This section only deals with emissions from diesel locomotives operation. Electric locomotives are powered by electricity generated at stationary power plants, as well as other sources. The emissions from stationary power plants are covered under the Stationary Combustion chapter.

Navigation (1A3d)

Greenhouse gas emissions should be estimated separately for domestic and international water-borne navigation. The international/domestic split should be determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.

1A3e: Pipeline transport



Category 1.A.3.e includes emissions from fuel combustion for pipeline transport activities. The list of fuels used directly as fuel in pipeline transport includes natural gas and crude oil. Carbon emission factors, corrections for partial carbon oxidation, and conversion factors for actual carbon emissions to carbon dioxide emissions are used in accordance with the IPCC methodology (IPCC, 2006). Combustion-related emissions from pumping stations and pipeline maintenance are the main source of emissions in this category.



1B Fugitive emission

Fugitive emissions (1B)

Sources of greenhouse gas emissions in this subsector are oil and gas facilities and the coal mining industry. They emit direct greenhouse gas emissions of the following types: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O).

Methodologies for estimating fugitive emissions from the Energy Sector are very different from those used for fossil fuel combustion. Fugitive emissions tend to be diffuse and may be difficult to monitor directly. In addition, the methods are quite specific to the type of emission release.

Solid fuels(1.B.1)

- 1.B.1.a Coal mining and handling:
 - 1.B.1.a.1 underground mines
 - 1.B.1.a.2 surface mines
- 1.B.1.b Solid fuel transformation;
- 1.B.1.c Other;

Oil and gas(1.B.2)

- 1.B.2. a Oil
- 1.B.2. b Gas
- 1.B.2. c Venting and flaring





Solid fuels(1.B.1)

This category covers all coal handling operations from **underground** and **surface coal mines** and **post-mining coal handling operations**, including methane utilization. It also covers emissions from solid fuels conversion arising from uncontrolled combustion at coal mines.

Methane and **carbon dioxide** emissions are main reporting gases

In underground coal mines, mine gas, methane, is very actively released, it is either dispersed or disposed of by burning on gas generators, deliveries to consumers, flaring, etc. If this coal mine methane is utilized, it will be subtracted from the total emissions from underground coal mining.

Tier 1 estimations are based on the country-specific data on the underground and surface coal mines, methane recovery, the number of sealed mines, and on the IPCC default values for emission factors.

Tier 2 methods are based on the information about underground and surface coal mined in the country and **country-specific emission factors** that account for country- or basin-specific data, such that **to take into account the gas content, national basin-specific** emission parameters, and the number of coal mines.

Tier 3 estimations use the information about underground and surface coal mined in the

Oil and Natural Gas(1.B.2)

This category covers fugitive emissions from oil and natural gas systems, including

- Fugitive emissions from oil (1B2a)
 - Fugitive emissions from gas (1B2b)
 - Venting and flaring (1.B.2.c)
- Exploration
Production
Processing
Transmission and Storage
Distribution
Other

Direct emissions of greenhouse gases from this sub-sector include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) (from combustion and exploration), as well as non-methane volatile organic compounds (NMVOCs), sulphur dioxide (SO₂), and oxides of nitrate (NO_x).

Methodological tiers

Tier 1 estimations are based on the country-specific activity data for the specified hydrocarbon fuel and on the IPCC default values for emission factors.

Tier 2 methods are based on the country-specific activity data for each hydrocarbon fuel and **country-specific emission factors** that account for the fuel's composition and activity values for the oil and natural gas systems in a country.

Tier 3 approach uses direct measurements of the parameters of hydrocarbon feedstock on the facility-specific basis and accounts for the specificities of the facilities' operations.



$$\text{Emission} = AD_a \cdot Ef_a$$

Emissions are CH₄ emissions (Gg)
AD_a is activity data;
EF_d is emission factor for operations with hydrocarbon feedstock (Gg/activity value).

1.B.2. a b Fugitive emissions from oil and gas

The sources of fugitive emissions on oil and gas systems include, but are not limited to, equipment leaks, evaporation and flashing losses and accidental releases (e.g., pipeline dig-ins, well blow-outs and spills). Leakage is viewed as unintentional emission through equipment leaks.



1.B.2. c Venting and flaring

This sub-sector estimates emissions from venting and APG and natural gas flaring

Venting are classified as organized regulated emissions associated with the technological features of oil and gas industry facilities. Venting are something planned and required by operational process or equipment repairing. Many companies do not distinguish between blowdowns and leaks and report them in a general way in the "process losses"

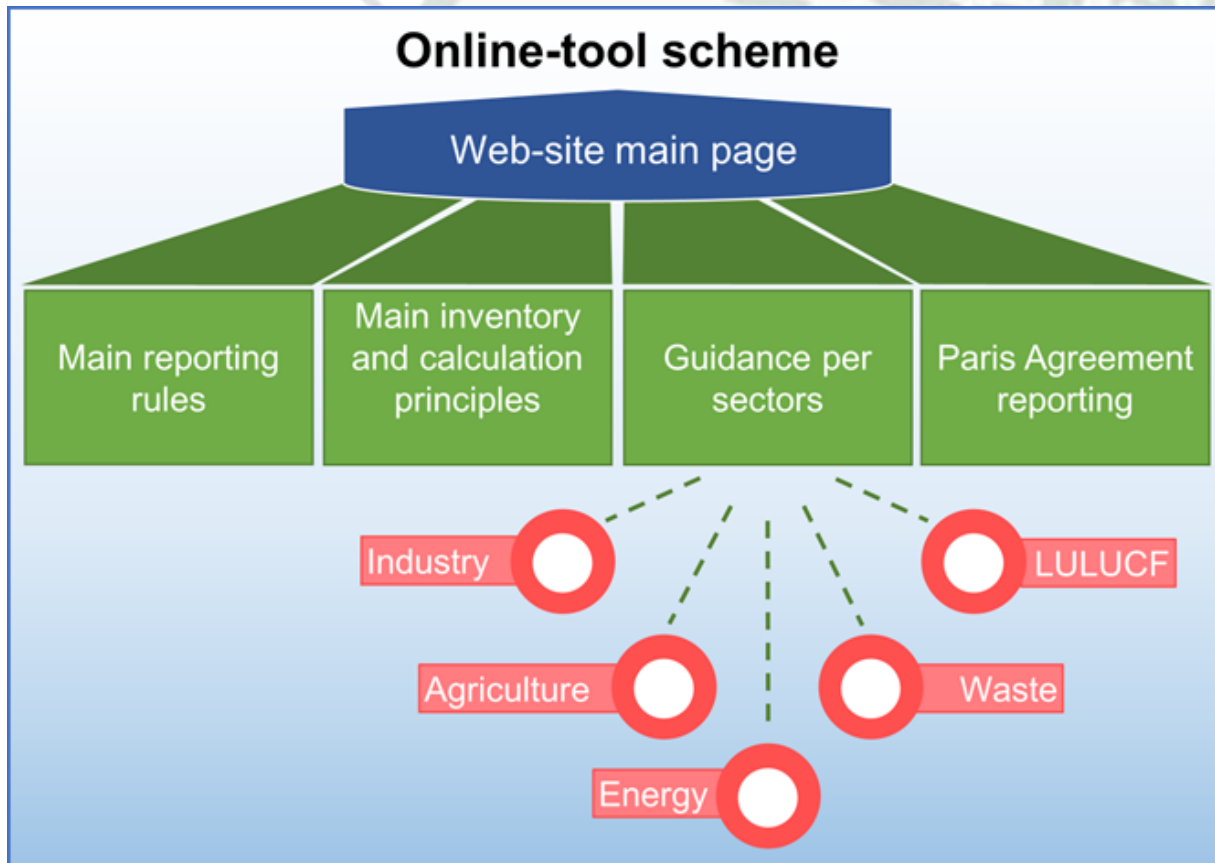




**Methodologies for GHG
emissions inventories and
Paris Agreement reporting**

escap.igce.ru

Supporting countries in Asia-Pacific countries to meet commitments to the Paris Agreement





Goal:

to support **Asia-Pacific** and other **non-Annex I UNFCCC countries** in preparation of the reporting, conducting of estimations of **Greenhouse Gas (GHG) emissions**

Web-access to sectoral methodology

ESCAP IGCE

ESCAP  Русский  English



Supporting countries in Asia-Pacific to meet commitments to the Paris Agreement


Methodological recommendations on the calculation of greenhouse gas emissions and preparation of reports for the countries of Central Asia, taking into account the Paris Agreement



Main reporting rules



Main inventory and calculation principles



Guidance per sectors



Paris Agreement

Sector guidelines

- 1 Energy Sector
- 2 Industrial Processes and Product Use
- 3 Agricultural Sector
- 4 Land Use, Land Use Change, and Forestry (LULUCF)
- 5 Waste Sector



Main goals of the Practical sectoral guidelines

1. Provide clear and simple explanation of main IPCC principles for each sector and category of the Inventory
2. Share the 20th years experience of the IGCE inventory team in preparation and reviewing of GHGs inventories in all sectors
3. Underline possible challenges which organizations responsible for the estimations and preparation of national GHG inventories could meet on
 - Inventory preparation
 - Activity data collection
 - Chose of estimation parameters and development of country specific emission factors
 - Inventory reporting

Methodological basis

2006 IPCC Guidelines for National Greenhouse Gas Inventories

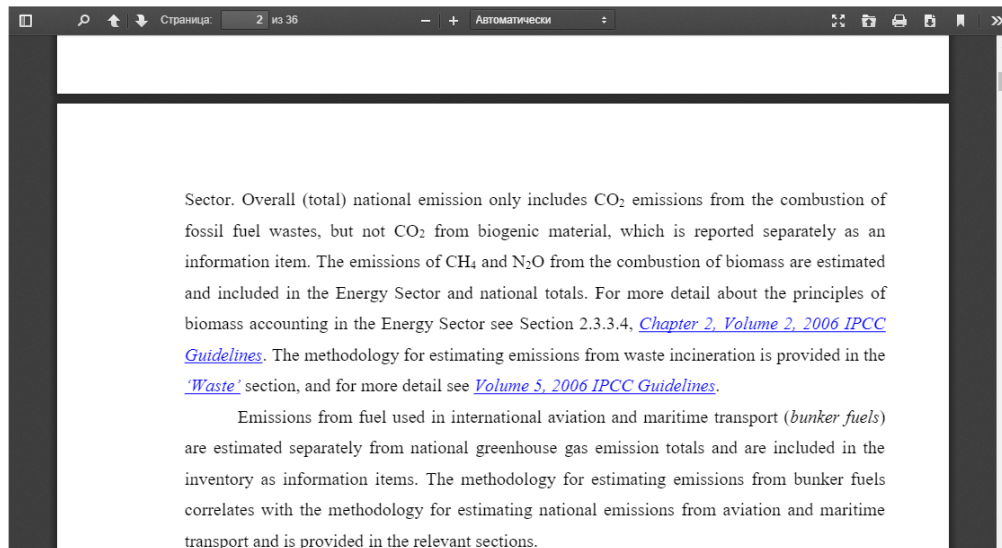
Additional methodologies adopted by the UNFCCC Conference of Parties also referred as appropriate

The Guidance contains references, clarifications, and useful tips to support the estimation and inventory efforts.

All links in the interactive version lead directly to the required section pages, original data sources, or useful supplementary resources

Where appropriate, approaches to, and examples of, using national methodologies which best reflect the national circumstances are provided, on condition that such methodologies are consistent with the IPCC Guidelines, scientifically based and properly documented.

Energy



Sector. Overall (total) national emission only includes CO₂ emissions from the combustion of fossil fuel wastes, but not CO₂ from biogenic material, which is reported separately as an information item. The emissions of CH₄ and N₂O from the combustion of biomass are estimated and included in the Energy Sector and national totals. For more detail about the principles of biomass accounting in the Energy Sector see Section 2.3.3.4, [Chapter 2, Volume 2, 2006 IPCC Guidelines](#). The methodology for estimating emissions from waste incineration is provided in the ['Waste'](#) section, and for more detail see [Volume 5, 2006 IPCC Guidelines](#).

Emissions from fuel used in international aviation and maritime transport (*bunker fuels*) are estimated separately from national greenhouse gas emission totals and are included in the inventory as information items. The methodology for estimating emissions from bunker fuels correlates with the methodology for estimating national emissions from aviation and maritime transport and is provided in the relevant sections.

Energy

CHAPTER 2

STATIONARY COMBUSTION

Structure of sectors/categories presentation

- Category description
- Methodological approaches to emission/absorption estimation
- Availability and short description of methodological Tiers
- Activity data
- Estimation parameters
- Cross-cutting issues
- Quality control procedures; uncertainties
- Reporting Tables
- Expert recommendations: problems related to calculations and common mistakes
- Availability of a refinement for a specific source category in 2019 Refinement to the 2006 IPCC Guidelines